國立政治大學科技管理研究所

碩士學位論文

R&D Sharing and Cooperation within the supply chain: the case of Taiwan IT companies

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Abstract

The purpose of this study is to better understand the functioning of knowledge sharing in the supply chain of Taiwan IT industry and face the current practice of modular component outsourcing with a theoretical threat of architecture change and modularity trap.
Today, modularity and component outsourcing became almost an prerequisite for an successful IT company. Product architectures are widespread and well defined. It is however the question nobody dares to ask – what if this changes? How can the Taiwan suppliers make sure, that they will still be in the game even if the rules change? How can they assure that their position as the cutting edge component providers won`t be taken by someone else?

The basic premise of the research is, that the relationship management of supplier and buyers often seen in countries with Confucian tradition can overcome this threat thanks to deeply rooted trust and good and opened communication patterns.

This paper first introduces the Supplier-buyer relationship theory and background on its functioning within the New Product Development (NPD) area. The study also touches on the issue of Early Supplier Involvement (ESI) into the New Product Development.
Next the theory on Modularity and Modularity Trap are introduced. Based on the literature review, I construct an research framework, consisting of two bodies: *The architecture as a variable* and *Buyer-supplier relationship and NPD*.

The major conclusions of this study are (1) The architecture of the product to be developed is an important driver on the supplier-buyer relationship creation.
(2) To build the relationship with buyers is important step for the suppliers, but it can only be build around technology that is important for the buyer. (3) Supplier`s understanding of architecture knowledge of its buyers is crucial. (4) The main reason to invite supplier into New product development is buyers technological distance between what they can have and what they want to have. (5) Product Complexity (number of parts and their interconnections within the product) have a positive influence on the supplier role creation. (6) All buyers have a rather good component knowledge. (7) The management alignment will be greatly influenced byt architectural attributes of the product to be developed.

Keywords: Architecture, Architecture change, Modularity, Modularity trap, Buyer-supplier relationship, knowledge management, New Product Development

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Chapter 1 – Introduction

This first chapter is to provide reader with basic overview on the topic and researched area. We will begin with discussing the research motivation and background on the topic. Next I introduce the research objective followed by more defined three research questions. Finally, the outline of the study is presented.

1.1 Research Motivation

As a student of innovation management, I often feel fascinated by the amount of coordination necessary to develop one single new product – not only the tremendous amount of managerial work inside the company but also the coordination with the outside partners who often posses critical assets.
In today business environment, we often hear terms like outsourcing and core competencies, the modular design and with it connected loosening of managerial alignment – these patterns are designed to ease the managerial coordination when developing very complicated artifacts such as IT and computers. However, such an approach wasn`t always the common practice in the industry and also its future is unsure.

A textbook example showing the shift from integral to modular is the case of IBM and its transformation in early 90`s. In the early 1980`s, IBM was more or less the whole computer industry, with only very few competitors to be accounted for. At this time, the company was building its products almost exclusively with internal capabilities and without help or interference of any other organizations. The company (same as its main competitors at that time Hawlett – Packard and DEC – Digital Equipment Corporation) was highly integrated. The companies tended to provide most of the key elements of their own computer systems – the products were closed to other developers and not compatible with each other. During this period, IBM`s business model was to provide the overall systems and service package, which kept all other competitors at bay – they were not able to compete with single product of better performance. In 70`s, IBM was challenged by Apple Computer, an young and small start up at that time. IBM` challenge was multiple - they needed to create a new product, a new process to manufacture it and also a new supply chain to feed the product and also distribute it at the same time. The issue of high costs arised and IBM, in order to keep the costs down chose the modular design with an modular supply chain. The design was mainly build around two companies – Intel and Microsoft. IBM moved from vertical integration to horizontal, and the dominant was no longer the IBM computer, but rather IBM *compatible* computer. This was very important move, opening the closed architecture to new entrants, who were free to join the game as long as their products were IBM compatible. This was the development, which lead to the shift to modular architecture in the computer industry and situation, where components designed and build by different parties were interchangeable inside the computer. The modular architecture created a great deal of competition within each segment of the horizontally structured industry. There appeared new sub-industries within the industry – not only for microprocessors and operation systems, but also for peripherals, software, network systems etc. And within each of this category, a new start ups and businesses emerged, making it much easier and more convenient for a computer making company to shop around just for the right combination of components, based purely on the design needs of the particular assembler.

However, the competition in modular industries is fierce, and inevitably leads to commoditization of goods – as they are all directly substitutable from other companies (competitors) with small or almost none switching costs. Therefore the competitors are mainly focused on their survival rather than on radical or even architectural innovation, which might well differentiate one`s products from the competition. This is the reason, why IBM has literally turned itself inside-out, becoming a merchant provider of the basic components and technologies it previously guarded so jealously for exclusive use in its own products (Sturgeon, 2002).

The reasons for such an shift, are threefold: modularity allows the different parties involved to manage the extreme complexity, it enables parallel work which is important for lowering leading development times in the product development cycle and lastly but not least – modularity is tolerant to uncertainty – which means that particular elements of the modular design might be change a posteriori the development, and in unforeseen ways as long design rules are obeyed (Baldwin and Clark, 2001).

1.2 Research Objective

Modularization and so called black box outsourcing was huge change to the business environment where the companies had to completely rethink their strategies in order to find suitable solutions to new situations. They often had to go from vertical to complete horizontal, changing the ownership of the old business units to new independent equities and often finding new sources from outside where their own were not up to the standard.
The greatest advantage of modularity is the ease of business exchange it introduces – there is not much all the partners need to discuss or change, since they are buying and selling modules that work in very similar way. This is very much true for both sides - buyers and suppliers – where the buyers have a range of sellers for the same component, where sellers once refused by one buyer can sell the very much same component to somebody else and easily switch the customer as long as they employ the same interfaces and standards.

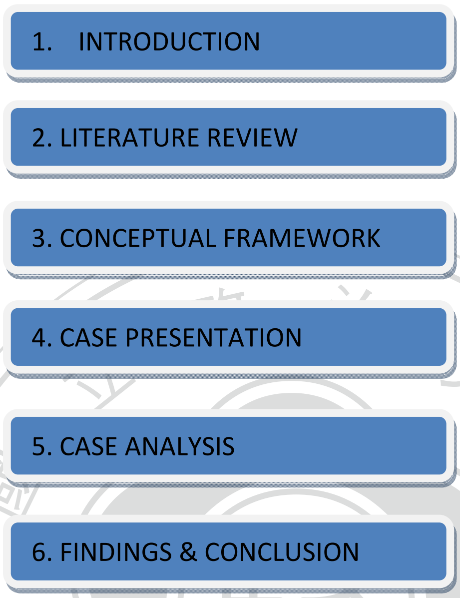
My question was - what would happen once the standards change? How can the suppliers react? How can they fast learn the new interfaces and procedures to deliver products needed? I employ the “Modularity trap theory” as described by Chessborough and Kusunoki and apply findings from the buyer-seller relationships studied in Japan and elsewhere in the world to research possible cooperation schemes between the possible suppliers and their customers in the knowledge based IT industry of Taiwan.

1.3 Research Question

- **Do all the companies manage their suppliers in the same way? Are all the suppliers same important?**
- **What are the main factors to employ the suppliers into the new product development? Under what circumstances are buyers more likely to work with the suppliers on the new product development?**
- **What are the main problems and challenges when managing suppliers in the new product development? Are there any risks involved when suppliers work in the new product development?**

1.4 Outline of the study

The outline of this study is divided into 6 chapters. By now, the chapter one is basically presented and familiar to the reader, therefore only the content of consequent chapters will be briefly discussed below. Figure 1 visualizes the outline of this study.



Source: this research

Figure 1: Outline of the study

The chapter 2 provides the reader with an overview of the literature related to the three research questions as well as on previous findings on the modular theory and modularity trap to provide the reader with necessary theoretical background.
Chapter 3 describes the frame of reference of the study, where in the light of the reviewed literature I do create a conceptual model for the study and subsequent research (and questionnaire) as well as an visualization of all the variable into a frame of reference. Also, I discuss the research method selected at this place.
Chapter starts with introduction of the four companies and their products and follows with the body of research, with presenting the cases content and data gathered during the interviews. I create a table with brief resume that summarize all the major findings at the end of this chapter.
Chapter 5 includes analysis and research findings, which were the basis for the conclusion and recommendations in the chapter 6.

Chapter 2 – Literature review

The previous chapter provided the background and outline of the study, clearly showing what is the problem I want to analyze and leading to specific research questions. In this chapter, I review earlier cases and papers from within my research purpose area.
The aim of this chapter is to provide relevant literature in the fields of modularity, modularity trap and supplier-buyer relationship management.

2.1 Buyer-supplier relationship and New Product Development

The study of supplier-buyer relationships was an important field of the management study in late 80's and early 90's.
The organizational studies were trying to explain the reasons why Japanese producers can be more efficient, have faster time to markets and overall higher innovative products with better quality than their American counterparts - even after the cost issue in Japan and US narrowed. Many studies point out that the reasons Japanese companies were able to get their momentum was due to their strategic and skillful vendor management.

This first part of the Chapter two is divided onto three major parts – on the *Supplier pool management*, *Time frame of supplier involvement* and *Development responsibility and scope*.

2.1.1 Supplier pool management

Here I introduce the reader with considerations connected on how to manage suppliers during the new product development. I will tackle on buyer`s considerations like how they choose the right suppliers, how they do analyze their capabilities and how to motivate them to be interested and participate in the project – creating an relationship with the selling company being an integral part of all of these considerations.

2.1.1.1 Supplier segmentation

Jeffrey Dyer (1994) in his essay on strategic supplier segmentation compares 3 models in the auto industry, all based on company nationality – his comparison includes Japan, Korea and American car manufacturers.
He defines two main ideas – the "*arm length*" and "*partner*" relationship. The *arm length* model is a traditional model, when buying companies (customers) try to minimize their dependence on suppliers and on contrary tries to maximize their bargaining power. The main idea is that the buyers *"deliberately keep suppliers at "arms-length: and avoid any form of commitment"* (Dyer, 1996)
This model was generally accepted as the most successful model of managing suppliers until the rise of Japanese firms, who did not use this model but they employ rather very antagonistic type of model.
The other side of the spectrum is the *Partnership model*. The Japanese companies can enjoy superior position to the American companies because they can share more information and better coordinate all related efforts when managing their suppliers as partners, as well as invest in relation- specific assets and lower the costs, improve quality and speed in the product development. (Clark and Fujimoto, 1991) The drawback can be that these partnerships tend to be more expensive to set up and maintain – and may reduce customers ability to leave such relationship once it meets the dead end.

The findings of Dyer`s study suggest, that historically the US companies managed their suppliers on the *arm-length* basis, where Koreans incline to use the *Partnership* model. It is interesting to mention, that Japanese companies (Toyota and Nissan) would mostly choose the relationship depending on the nature of the component – and it were only Japanese companies, who would strategically segment their suppliers in such a ways, that they could benefit from both arms-length and Partner relationship. (Dyer, 1996)

In his further works[1], Dyer suggests to segment suppliers into several groups according to the output they provide. The first group are suppliers, who provide necessary, but non-strategic inputs where the other group provides strategy inputs. The meaning of strategic inputs are inputs, that are directly connected with the core competencies of the purchasing firm and may be useful in differentiating the buying`s firm product in the marketplace. This second group would form suppliers applicable for the *partnership model*. (Dyer at all, 1998)

This idea was further developed by the revolutionary work of Rajan R. Kamath and Jefrey K. Liker. Their paper first time appeared in the renowned Harvard Business Review, and set up a

[1] Dyer, J.H., Cho, D.S., and Chu, W. (1998), "Strategic supplier segmentation: the next 'best practice' in supply chain management", *California Management Review*, vol. 40 No.2, pp 57 – 77.

starting position in supplier management and assessment of their abilities and segmentation. Kamath and Liker studied suppliers of the leading Japanese car companies, their business relationships as well as how can these relationships shaped during the time. They came up with four supplier roles, based on the competencies the car maker expected from these suppliers. This is important and it show us, that there will be different relationship and trust models between different companies. These are partially based on the technology the suppliers provide, but they also state, that these might change over time – depending on to what level the supplier wishes to bring the relationship and what would they do for it.

They even strictly state: "*Not all suppliers are equal*" – meaning that the car company would expect different complexity products from different suppliers and would not ask them to participate on projects, if the complexity is far beyond the suppliers understanding and capability. Only a very small and elite group of the first tier suppliers does actually participate on the product development projects (typically Japanese automakers would have around 100 to 200 first tier suppliers) and these suppliers are merely treated as equals to the brand companies.

Of course, this is connected with their size and thus their ability to actually participate and invest into special tools necessary for product development necessary to keep such an relationship (such as CAD, prototyping facilities and R&D capabilities). These suppliers must be valuable for the customers, so the customers would actually keep them on their list for future project developments – in case they are not able to deliver any value added, and instead specialize in assembly etc. they are easy to replace. The superb component knowledge and development capabilities are what the suppliers invest into these relationships. Of course, this implicates risks for the suppliers, since they need to decide what technologies to develop and what are the important investments connected with these. Therefore, the top suppliers must be very selective and choose their clients accordingly.

2.1.1.2 Supplier Roles

Kamath and Liker (1994) introduce the following four supplier roles. At the same time they note that these roles may not same for every relationship – some companies might choose to become an partner with their customer (or even on the component level) to develop certain product critical for their (supplier`s) future, but in regards to other companies (or components) they might choose Mature or even Contractual role. This all depends on the strategic motives of the supplier and also the nature of its relationships with its customers.

Table 1: Supplier roles

Four Supplier Roles

Role	Description	Responsibilities During Product Development
Partner (Full-Service Provider)	Relationship between equals; supplier has technology, size, and global reach.	Entire subsystem. Supplier acts as an arm of the customer and participates from the preconcept stage onward.
Mature (Full-System Supplier)	Customer has superior position; supplier takes major responsibility with close customer guidance.	Complex assembly. Customer provides specifications, then supplier develops system on its own. Supplier may suggest alternatives to customer.
Child	Customer calls the shots, and supplier responds to meet demands.	Simple assembly. Customer specifies design requirements, and supplier executes them.
Contractual	Supplier is used as an extension of customer's manufacturing capability.	Commodity or standard part. Customer gives detailed blueprints or orders from a catalog, and supplier builds.

Source: Kamath and Liker, 1994

Partners are the top on the list and they often also are the leading companies among the suppliers. They might be thought as a full-service providers, who are responsible for development and coordination of whole subsystems. Since in Japan, the car makers would frequently communicate only with the first tier suppliers, these suppliers are than responsible for further coordination on these projects.[2] They usually participate in planning a new model even before the concept stage. It is very common, that the their understanding of own processes and – and their component know-how and technological capabilities are far superior to their customers and it is often *Partner*`s, who suggest solutions to meet their customer`s price and performance objectives. They have their own testing capabilities, and they also help

[2] Although this has been changing in recent years as the consequence of the worsening economic situation – some of the companies are actually pursuing strategy called "Cherry picking" – the automakers would purchase suitable components from 2nd or even 3rd tier suppliers and buy them by themselves – and then provide these to the 1st tier suppliers for assembly into the new subsystems. This allows the car makers to "cut ff" the 1st tier suppliers margins added on every component purchased by them.

out with the customer parts testing, as their insights might be beneficial. (Kamath and Liker, 1994) These suppliers are an “arm of the customer” –even during the pre-concept phase the *partner* and the customer jointly determine the specifications of the subsystem – and because of the complexity of the subsystem – and its connections to the other parts of the whole system – the *Partner* must open intensive communication channels with the customer. The common strategy of Customer having supplier`s engineers present on their plant is mostly the case of *Partners*.

The Mature role in supplier distinction is very similar to the Partner`s, however the main difference is in their lack of technological capability of Partners. They are able to develop very advanced technologies, and they are able to accommodate most of their customer`s needs, however they usually are not able do so alone and mostly they also don`t participate during the pre-concept stage – their technology background is not so strong, they may lack some of the necessary capabilities (such as dedicated R&D centers, deep knowledge about the customer`s technology etc.) and thus lack the technology insight required by customer to invite them to participate on the pre-concept phase. Still, they are able to develop systems in the cars based on a clear specifications given by the customers, and they are given a big freedom in doing so – as long as the system meets the rough specifications given by the customer, the Mature supplier is free to be creative. They do posses an extensive testing capabilities and the customer absolutely trust their results – they might not verify the data the Mature supplier provides along with the prototype – the customers simply trust that they are correct. The intensive communications between Mature suppliers and Customers however begins one step later than in the case of Partners – namely at the concept stage and then continue to the production

The *Child* role influence over the design in the product development phase is even lower. Although it might be possible for the Child supplier to have a limited participation during the concept stage, this would be for consultations on a very specific design issues, or to provide insights thanks to their expertise commonly connected with procedures or materials. Also, the extent of these consultations would be rather low, with one or two meetings only and it is the customer, who will actually do the final decision – these consultations are of informational character only. Their major responsibility is to work out the details of the design and building up the testing prototypes. The customers will do on their own internal assessment of the data provided by the Child supplier among the prototype. As well the communication among the supplier and customer is rather low until the prototype and production phase, when it would eventually increase on intensity. Still, it won`t be of that intensity as with the Partners or even Mature suppliers. These supplier roles are often eligible when manufacturing part or systems that are very simple (and therefore does not involve much of coordination with others) or with only very little technology change – therefore no need for extensive communication and coordination. Often, these suppliers are simply not that big as Partners and Mature, so they simply cannot afford the huge investments into the development of new technology. Still, there might be cases of Mature or even Partner suppliers, who choose to pursue this (*Child*) strategy for some of their technologies, where they don`t see any further possible development, and thus it would be futile to further invest into it. On contrary, they would simply try to "Milk the Cow" – get as much as possible from an old technology and abandon it once its useless.

The Contractual supplier role is the lowest in the above presented chart – they simply manufacture parts based on exact customer`s requirements – which position these suppliers among the standard parts or commodity manufacturers. This is mostly the case, when they posses some sort of competitive advantage in the production capabilities (e.g. large scale automation) and the customer simply transfers his design over to the supplier so they can enjoy the low prices and higher flexibility than doing these parts by themselves. There is no need to communicate in the pre-concept and concept stage, there might occur some communication in the late prototype stage as well as during the production phase, though the communication activity is still much lower than with the other roles. Supplier, who produce easy, routine products does not need to be treated as Partners. Although the suppliers often make their target to move up in the ladder this might be a very expensive and dangerous move from their current position. Since they need to broaden their technology base and also invest heavily, they should strategize ad choose their customers for such a move carefully.

It is important to note, that even though it might seem, that the health of the relationship is crucial to obtain the business with the customer, it is not the only variable. Often, more suppliers compete on the same project and only the best will be granted the project – often the engineers dispatched to the customer on the supplier`s behalf find out, that they work along with other supplier`s engineers during the design, but sometimes even during the production phase. This might be true for all first three supplier roles (Partner, Mature and Child). This is due to the fact, that although the relationship is important for both suppliers and customers, it is the actual value the suppliers give to the customers that matters – not the other way around.

Timothy Sturgeon (2002) in his breakthrough essay "Modular Production Networks" creates a very similar concept to the Partner Supplier of Kamath and Liker. He calls these the "Turn-key" suppliers.

These suppliers evolved from a great number of smaller companies, that evolved from the outsourcing era of late 90`s. The leading firms (customers) were undergoing the process of re-structuration – they were getting rid of non-core asset or assets where they were not competitive at all. As a subsequence, these leading companies would specialize on their "*core assets*" only. In the beginning, the industrial landscape seemed to be characterized by a great number of small companies, that will choose to be highly specialized in one of these shed “*non-core competencies*” and these would ultimately become their own “*core competency*”. This however did not happen.

These suppliers, in order to meet their customer`s growing demands for full-service outsourcing solutions, had to invest heavily into their technology development and often develop their competencies not only in few, but rather in many competency areas so they would meet their customer demanding needs, who would often outsource whole systems. Of course, hand in hand to this trend, they also had to push down their costs, rise quality, delivery as well as increasing their scope of activities. This deepened the knowledge and abilities of these suppliers, however without much of assistance, or even dependence on the leading companies. Not necessary to mention, that this increased outsourcing, as well as having a great number of similar customers with similar products allowed these suppliers to grow significantly.

“*Thus outsourcing has led to a deepening of competence and increase in scale at supplier firms*” (Sturgeon, 2002)

Table 2: Supplier roles in Product Development

Supplier Roles in Product Development

	Partner	Mature	Child	Contractual
Design responsibility	Supplier	Supplier	Joint	Customer
Product complexity	Entire subsystem	Complex assembly	Simple assembly	Simple parts
Specifications provided	Concept	Critical specifications	Detailed specifications	Complete design
Supplier's influence on specifications	Collaborate	Negotiate	Present capabilities	None
Stage of supplier's involvement	Preconcept	Concept	Postconcept	Prototyping
Component-testing responsibility	Complete	Major	Moderate	Minor
Supplier's technological capabilities	Autonomous	High	Medium	Low

Source: Kamath and Liker, 1994

2.1.1.3 Supplier`s influence over the design

As mentioned earlier, the suppliers may have some influence on the overall product architecture – due to their possession of some critical or strategic component, their extensive and unique insights into the technologies which might come handy during the early stages of the product development or simply due to their relationship with the customer, who might be willing to listen to them due to the long term cooperation history.

Kamath and Liker (1994) mention, that it is usually only the Partners who might have some actual and intended influence over the end architecture – they have the scope, posses great deal of technological knowledge which is praised by the customers as well as they usually provide the customers with system or subsystem solution of strategic importance, and it might be too costy to alternate these instead of changing the overall design. In this way, these companies are real equal counterparts to the customers and their negotiation power is huge – they have the strength to negotiate the customer into the direction they wish.

The Mature suppliers might have chance to influence the end design to their favor, but this influence is only very limited and usually they would have to reach some sort of understanding with the customer – their technology capacity is not that strong as of Partners and they don`t have the strength to make the customers move in the strategic direction they would like to. Instead, its usually them, who would follow the customer`s strategic vision and develop the products as the customer wishes. Still, since they do understand the technology rather well as well as they posses quite good architectural knowledge, they have the strengths to raise their hand and point out possible problems to their components originating from the architecture design flaws – and have the customer change these.

The importance of the Child and Contractual is rather low and also their influence over the overall design is rather negligible. They develop the components based on the blueprints and even though they posses good component knowledge, their understanding of th overall architecture is usually superficial and thus they are not in position nor expected to raise concerns about their components functionality within the architecture.

2.1.1.4 Reasons to integrate

The following or similar definition of early supplier integration (ESI) into New Product Development was often used in number of studies about this topic. As we can see, it mentioned two major management issues – namely the co-decision making ability as well as free information sharing. In the text below, we will see why and how to do so.

'Supplier integration into new product/process/service development suggests that suppliers are providing information directly and participating in decision-making for purchases used in the new product/process/service. This integration can occur at any point in the five-stage new product/process/service development model.' (Ragatz et al, 1997)

ESI usually occurs at an early stage of the life cycle of product, generally at the time of product concept or design. This cooperation has usually a form of specific vertical coordination, when manufacturers involve suppliers. (Bidault et al, 1998)

There are numerous reasons to involve suppliers into the New Product Development. The main is often reducing new product development times – by using the supplier`s technical capability as well as many "off the shelf" components instantly available through the suppliers instead of going through new product development for these.
Others might be managing the costs, by giving out clear targets and discussing these with suppliers – they might be more insightful about what is realistic and what not.
Improving the product quality is also important consideration – since through early supplier integration can open a new channel for quality evaluation and management.
Collaboration allows for cross-disciplinary integration, which might be essential for creating really new and innovative products.

There are however some drawbacks of ESI as well. Such might be increasing product and development costs, mismatching resources and involving suppliers into improper tasks. Significant issue would be organizational resistance and different corporate cultures nd most notably – selecting incapable suppliers.
Also, involving only single supplier in development of crucial, strategic components of new system might be seen as a risk – due to increased asset specificity of such an supplier and his strategic importance to the customer, who might become captive in such an relationship.

Product modularity strategies are influenced not only firm`s idiosyncratic capabilities but also other parties in the supply chain (e.g. suppliers, competitors and customers), hence technological changes in components introduced by one supplier would certainly affect the performance of the system as a whole. (Hsieh, 2002)

For the suppliers, there is much more work and risks involved than for customers (OEM`s). This is due to the fact, that it will ultimately be them, who will provide most of the knowledge and do most of the work. For an supplier, it is a big question to answer whether they want to be part of the NPD or not. And in case yes, than under what conditions and why. As for the modular design, the risks of developing a new module or even system, but than being exchanged by the buyer for cheaper market option is just too high – they could simply wait for their competitors to develop the particular component, and than adapt to it once they got the chance to do so from the customers.

Therefore, it is crucial that they choose only projects, that are compatible with their future strategic plans –in the knowledge based technology the suppliers cannot risk that they would be replaced by the customers in the future because their technology knowledge is not up to date.

Velso and Fixson (2001) studied different companies in the car industry to find out, that more than often it is suppliers who foster the innovation. The reasons are, that under the modular conditions, they might develop new component, which might be compatible with other customer systems (thanks to the industry wide *design rules*). Therefore participation on such a new project would not only give the supplier competitive advantage over its competitors, but would also allow them to reach the economies of scale necessary for production of the new components as well as an pool of new customers.

Sometimes, their reason might be much more prosaic – Kamath and Liker mention case of Nipondenso, supplier to Honda, whose company mission is to be the best company in the industry. They would simply participate in most of the NPD projects, since they cannot accept the shame of becoming Tier II supplier in certain areas and thus losing their professional prestige. (Kamath and Liker, 1994)

2.1.2 – Time Frame of Supplier Involvement

One of the most important strategic decisions when considering the supplier`s involvement is – when to involve what suppliers?

Different literature suggest (Bozdogan et all, 1998; Ragatz et al,1997; Monczka et al, 1998) that supplier integration (1st tier supplier, or up-front supplier) into the New product development as early as during concept exploration and definition phase can foster architectural innovation.

It was shown both through theoretical modeling as well as through empirical research, that the timing issue is truly critical - and the earlier the suppliers are invited into the product development, the higher the chances that this product will be successful (Kamath and Liker, 1994; Bozdogan et al, 1998; Monczka et al, 1998; Clark and Fujimoto, 1991). Even though the customers possess and could obtain a huge amount of information regarding the components, they would have a great difficulties in accumulation of component know how – which is crucial for the new architecture development (Takeishi, 1998).
The leading companies can not possibly have expertise in every possible field they operate, and therefore there would be a lack of expertise in case they would chose a pure integral new product development. On contrary, as the consequence of years of outsourcing, customers usually don`t have any deeper knowledge of the components and the processes behind them. Fine and Whitney (1996) describe this situation as *Dependence for Knowledge* – the company needs the item, but lacks the knowledge of how to do it by itself. This is in bright contrast with *Dependency on capacity*, when they have the knowledge and only lack capacity (time, space, machinery or even management attention) to do so internally. (Fine and Whitney, 1996). Therefore, if involving the suppliers for the new product development, the buyers still can concentrate on development of their core competencies and don`t need to obtain deep level of information an work on the know – how development (to get the tacit knowledge as well) about every specific component – since they might benefit from their supplier`s component knowledge.

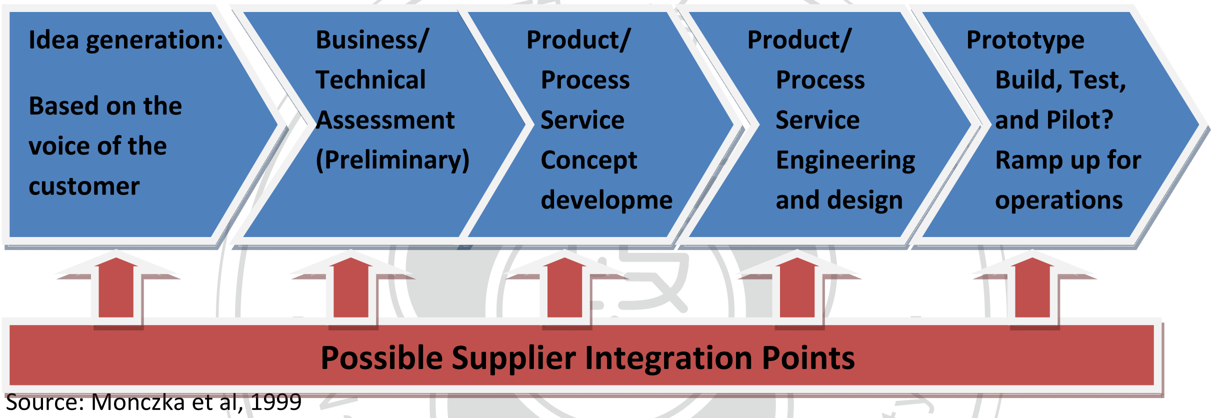
In general, there are two major factors to consider when evaluating about when the suppliers should be invited into the product development process (Monczka et al, 1998).

- The rate of technology change
- Level of supplier expertise in the given technology

In situations, when the component is under rather very turbulent and significant technology change and where there are high risks that the change in the component might impact the whole product (system), the integration of such supplier should be delayed in the product development cycle.

However, if the supplier`s expertise is significant and they might be an source of important or even key insights during the product development – than they should be included early in the process.

The table below shows generic new product development process supplemented with a matrix for supplier integration. The five stages shown in the figure below (Idea Generation, Business/Technical Assessment, Product/process/Service Concept Developmen, Engineering and Design, Prototype) often overlap, and usually there is some movement back and forward, as different ideas are created, tested, verified and either accepted or declined into the new product. Thus, this picture is a simplification of the main processes and merely visual conceptualization of the whole and complicated process, which new product development is.

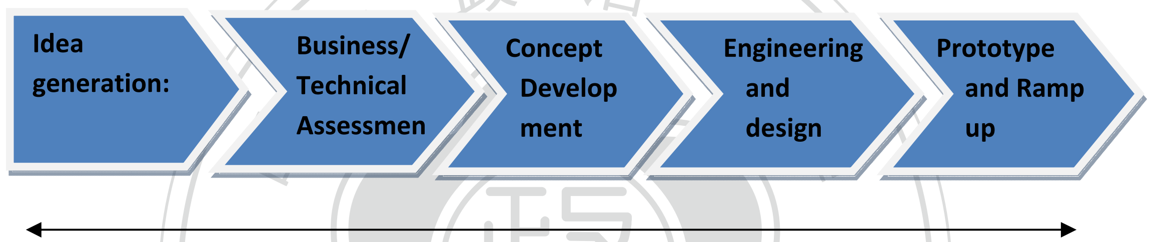


Source: Monczka et al, 1999

Figure 2: New Product Development Process

During the first stage the multidisciplinary teams (mostly consisting of product marketing, market intelligence, industrial design and physical design disciplines) would research the customer`s ideas and input on what might be the end product/service/process good for, how much should it cost and so forth. They will also take their technology road maps into consideration and market forecasts. At this point, the potential technologies might be assessed as well, especially in the case if an existing supplier posses an exciting technology which might give a competitive advantage over the competition. Business/technical assessment is a tool, which the developers may use to identify technical solutions of the product as well as their business feasibility. Third phase the product specification is the finalization of the product and once finished, the specs of the product are "frozen" – the product concept is finalized and the team will move from "what are we about to do" into "how to actually manufacture it". A preliminary concept might be developed for the purpose of concept definition. After this, the engineers from both the supplying and buying organization will start working on the blueprints and design specifications – and a working prototype is about to be created, which will enable testing an verification of existing production systems. Once this done, the product is finalized and is moved into the full scale production.

While the first two stages of the of NPD are relatively inexpensive compared to the later phases, their significance is that they will decide and "lock in" as much as 80 percent of the total cost of the product. Since the decisions made early in the project development will impact the later engineering solutions and thus influence product quality, costs, cycle time etc, it is important for the firms to take into consideration as many product processes and technical expertise as possible early in the NPD, when changes will be quite inexpensive and easy to do. Later on, it becomes very difficult and expensive as well to make design changes. (Monczka et al, 1999, Bozdogan et al, 1998)



Earlier

-Supplier of complex items
-Supplier of systems or subsystems
-Supplier of critical items or tech

-Strategic alliance supplier
-"Black box" supplier

Later:

-Supplier of simpler items
-Supplier of single components
-Supplier of less critical item/technology
-Non-allied supplier
-"White box" supplier

Source:Monczka et al, 1999. Pp 78

Figure 3: Integrate suppliers at different stages

2.1.3 Development Responsibility and Development scope

In this part the literature connected with the development scope and ways of suppliers are integrated into the NPD are presented. Every NPD project is different, and therefore also the managerial considerations should differ from project to project. It was suggested by the literature not to employ the same approach every single time, but rather use specific guidelines to choose the best approach for that particular project.

2.1.3.1 Management alignment matrix

A number of research papers (Monczka et al, 1999, Dowashahi 1998 etc.) indicate, that in order to successfully integrate suppliers into the New Product Development, the suppliers must be tightly integrated into the product project so that the developing team can benefit from all the component knowledge possessed by the supplier.
They propose so called cross-functional development teams that will create an counter balancing body towards every company`s own R&D team, working as an negotiating body between the all firms, trying to find the best solution for the project and thus lower the level of opportunism every company will try to raise. Also, they mention that in order for the project to be successful, a full time involvement of the top management is necessary. The top management role is to litigate the risks – in situations the targets and goals are unsure and the developers might even start to question their work and goals, it is the top management role to provide with leadership support and vision to show the clear aim of the project so that the whole team won`t flatter.
This, however can be the case of very innovative projects, that involve high risks and not clear idea on the targets and goals of the project.
Would this however be the case for all of the projects where suppliers are involved? Would this be the best practice even in cases of products with lower complexity and lower innovativeness, where the speed of consultations with suppliers might not be that crucial and on the other hand would only bring another layer of technology consideration and confusion into the project?

Olson et al. (1995) argues that the degree of the innovativeness (or product newness) is an important moderator of the impact of different coordination structures on the development process and its outcomes. Their research finding is that different levels of technology, newness and complexity in the products to be developed will determine the organizational structure of the development team as well as the immediate cooperation pattern between the companies and bodies involved in the project. This findings indicate, that and relationship management, with ties between the top management of both companies and than good connections among all the functional levels of the companies will be only for the ,ost important group of suppliers – who possess technology, innovative capacity or both.

In their study, Olson et al. (1995) base the major cooperation platforms on the typology of some heavyweights of the organizational theory – on the works of Nathanson and Mintzbeg.

Bureaucratic control/hierarchical activities is the most formalized and centralized as well as the least participative form of all the cooperation forms. All the mechanisms stay on the standard operation procedures and the oversight of high level manager who will coordinate all the activities across the functions. Most of the communication flow is vertically within the department and the general manager serves as the primary communication link and arbiter of conflicts across functions.

Individual liaisons is a coordination structure, where individuals from one or more departments are assigned to communicate directly with their counterparts from other departments. This supplements some of the communication need from the bureaucracies – making the information flow a bit faster as well as less formalized form.

Temporary task forces is basically the institutionalized form of individual liaisons – of the repetitive interaction between these contact within the context of specific project. Since the task force members represent various functions and interact directly, this form of alignment is quite interactive, participative and much less formalized than those above. Still, high level managers would still retain authority to govern these task forces by assigning tasks, imposing directives and mediating disagreements among members.

Integrating manager is an additional management position superimposed on the functional structure – he will be responsible for coordinating the efforts of various functional departments but won`t have any the formal authority to impose the decision on those units. These managers are usually very strong in their negotiating skills – since they don't have any other means how to make things happen!

Design teams bring together a set of functional specialists to work on specific new product development project. Such a team, however is rather independent and is more or less self-governing unit. The members have greater authority to choose their own leaders internally, instead of having leaders point out from outside their structures. They have free hands to choose their own procedures based on what they believe would be the most suitable way to the goal and would resolve any conflicts through discussions and consensual group process.

The relatively organic mechanisms such as *design teams* have some particular advantages for coordinating product development. The open minded atmosphere, participative decision making and consensual conflict resolution, where everyone has the right to point out possible

problems to his/her part in real time can foster innovative ideas creation and proposition. These might be discussed right away and either accepted or refused based on educated discussion. So the chances that such an team would come up with innovative and very new products, that would address adequate market niches or needs is quite high. Furthermore – since the discussions start early, critical issues, that might become problems later (e.g. during the manufacture phase) might be tackled right away and thus lower or negate their impact.
On the other hand – there are some disadvantages to this way of management alignment – in terms of costs and temporal efficiency. Creating a number of such a teams – where all would have the background necessary for their work as well as staffing them with highly skilled specialist might drain necessary resources that might be better employed somewhere else. Also, the discussion based approach can be rather time consuming and less efficient than more centralized forms of management – which might be an issue when developing products with short development cycles.
In this way, considering the innovativeness as a variable, themore participative structures are likely to improve the effectiveness and timeliness of the development process when the product being developed is truly new and innovative. However, the model also predicts that more bureaucratic structures may produce better outcomes on less innovative projects, such as those involving line extensions or product improvements. (Olson et al. 1995)

2.3.3.2 Degree of knowledge Sharing

Fine and Whitney (1996) believe, that the assemblers (buying companies) should rely on their suppliers for tasks only, but not for critical knowledge. If the companies follow such a strategy, they could live with outsourcing without fear, that the suppliers will gain more negotiation power during the purchasing of components. Also this is the way they can mitigate the risk of being surpassed by more potent suppliers, who will over the time overpass the former customers position and replace their position.

Another risk might be the possibility of losing the control over the technology so it will spill over to the buyer`s direct competitors through the supplier network so the design will lose some of its novelty and competitiveness. Fine and Whitney 1996) argue that there are two basic forms of dependencies: dependency for capacity and for knowledge[3].

Based on these arguments, Takeishi (2002) introduced the concept of “Knowledge partitioning”. He argues, that even though the companies might share some similarities between them in

[3] I described these in earlier part of this paper and won`t be doing so again here.

their knowledge areas necessary in order to co-create the product, knowledge partitioning implies that different organizations have control over different knowledge spaces and also over different tasks (Takeishi, 2002). The bottom line is that knowledge is not always homogenous and there is nothing like one same knowledge, that can be applied onto differing areas. On the other side, knowledge might be separated into independent parcels containing mutually contradictory information within the same area. We can say, that every company is an independent entity, with specific set of knowledge that will determine its modus operandi and thus the way they create value.

However, typically any one company does employ suppliers in development of products, and therefore the total knowledge necessary for the artifact creation won`t be present in one company only, but to get the complete picture we would have to cross the boundaries of companies if we want to gather all the necessary knowledge necessary to create the end product.

This is often the case – companies would try to reach out for more knowledge necessary to develop the products.

This is the rationale for Takeishi`s (1998) observation, that companies should go and try to gather some more of the useful knowledge beyond their boundaries – both sides need to acquire knowledge of their partner`s products, be it components providers or suppliers. In other words – the firms should know more than they make in order to stay competitive and there should be an overlap in knowledge between the supplier and customer when new technologies are to be developed.

This also means, that they will have to develop common language to open the channels of knowledge sharing. There is strong uncertainty in every new product development on goals as well as processes that would lead to these goals, the companies must communicate openly with their counterparts in order to mitigate these.

Takeishi (1998) suggests that it is particularly important for customers (buyers) to have a higher level of component-specific knowledge when the project involves new technology. In general the assembler's capacity to integrate all the components into one system might be increased by their greater knowledge of components, particularly when the project involves the task uncertainty with development of new technologies.

The same logic applies to suppliers – higher level of architecture knowledge by suppliers should increase the likelihood that they will be more ready for the problem solving necessary when faced with new project development requirement by the architecture integrator and thus being seen as an best suited supplier to provide with the right problem solution. Takeishi (1998) writes:

“*Building up architectural knowledge about the component was recognized as a critical success factor for suppliers to win design competition*”

2.2 On Modularity

This section deals with the general concept of modularity so to provide the reader with solid background information on the research. Even though theory of modularity is fairly simple, I spend quite a lot of space to cover this topic thoroughly, so that the reader can get a deep understanding of all the challenges in modular product development. The basic modular theory is introduced followed with the major challenges to modularity – the architectural innovation and the modularity trap.

2.2.1 Theories related to Modularity

Modularity can be seen as a general concept, which help us understand systems and their organization. According to Schling (2000) modularity is an abstract term (a continuum) which describes the degree, to which system`s components can be separated and recombined. Therefore all systems are characterized by *some* degree of coupling between components, and only very few systems have components which are completely inseparable and cannot be recombined. This is the reason we can say that almost all systems are, to some degree, modular.

Simon(1995) in his pioneering research shows examples of modularity from very wide specter of situations and postulate, that modularity might be found in almost all entities around us – social, biological or technological. Simon use the familiar example of biological organism to introduce the very basic concept of modular system and its ability of decomposition - *“which is composed of organs, which are composed of cells, which contain organelles, which are composed of molecules and so on.*

Simon use the term “hierarchically nested systems” – meaning that at any unit of analysis, the entity is a system of components and each of the components is, in turn is a system of finer components, until we reach a point, where the components are “elementary particles” or until science constrains our further decomposition (Simon, 1962).

Important aspect of the modularity concept is the *Separability*. As said above, almost all systems might be separated, although much functionality might be lost during the actual separation (e.g. during autopsy of a living organism, separation of some more crucial organs would lead to constrains or even system failures of that particular organism). The crucial question is, whether the systems can be put back together and still be functional in the same manner, as before – and is it necessary for them to be re-configured in the same, original way to keep working? This is where we can differentiate between the high and low levels of modularity (Sanchez, 1995).

High level of modularity are those systems, whose components might be disaggregated and recombined into new configurations – and possible substituting many new components into the configuration of the system with minimal or none loss of functionality. These components are relatively independent on each other, and the only dependence is to the overall system – the architecture of the system.

Still, there always will be some configurations, which would be more powerful – the components in that particular combination would overall provide better system output than other configurations. This optimization is a crucial concern during the design of modular artifact. The designer must take into consideration the possible advantages (trade offs) of fully modular and decomposable product, or product with lower modularity, however having possibly higher efficiency. Schling (2000) describes such phenomena as "*synergistic specificity*". These are situations, when through the combination of components we can achieve functionality unobtainable through combinations of more independent components (components with higher modularity). Such an architecture functions will be unchallenged by more modular systems, however later changes into these architectures are very difficult to do, as the components are more tightly organized and more deep interconnected.(Schling, 2000).

Baldwin and Clarke (2000) define modular systems as systems, which are composed of units (or modules) that are designed independently but still function as an integrated whole.
Modularity means building complex products or process from smaller subsystems, that can be designed independently yet function together as whole. They do n comprehensive research of the different communication patters among the components, but also companies responsible for them.
The modular design allows the creators to use components designed by other entities than the creators (people, but also companies or organizations) so the end product will still work – this is due the compatibility of the components with each other and the interfaces.
Since not only one company is usually in charge of more complex products, this brings us to knowledge management and information sharing across these organizations. Baldwin and Clarke (2000) specify different types of information, accessible to only selected classes of users or designers – the *visible* information is the architecture designed by the architect. This information is accessible to everyone who wants to participate on the modular design, and the

participants must follow it in order so their modules would be compatible with the overall architecture. The *hidden* information however is created by the designer of the module, and they do not need to enclose it to others – since this would leverage their competitive advantage. In plain words – as long as the component is functional within the architecture and follows its purpose, its designers does not need to share any more information than necessary. The visible design rules are therefore decisions, that affect subsequent design decisions, and they should be specified early in the design process and communicated broadly to those involved.

Visible rules might be further divided into 3 categories:

- *Architecture* –specifies what modules will be part of the system and what their functions will be
- *Interfaces* – that describe in detail how the modules will interact, including how they will fit together, connect, and communicate
- *Standards* for testing a module`s conformity to the design rules (e.g. can module X function in the system?) and for measuring one module`s performance relative to another (how good is module X versus module Y?)

The hidden design parameters are decisions, which do not affect the design beyond the local module – they have no influence over any other modules. They can be chosen late and and changed often and they do not have to be communicated to anyone beyond the module design team – so long they fit the original architecture and do their functionality does not interfere with any other modules in the system, or they change the functionality of the whole system. In other words, the hidden rules might be also described as component know-how.

The standards are the main advantage of the modular design. Once established and articulated to the suppliers, they allow a face speed competition as well as price reduction and innovation – since they allow numerous firms to experiment with a variety of implementations, and this resulting complexity far exceeds what could be produced inside a single firm. This experimenting and miss and match process allows a great deal of innovation, and the development of an product platform is much speeded. (Chessbrough and Kusunoki, 2001)

2.2.2 Modular product design and Modular Organization Design

Literature differentiates between Modular product design, modular organization design and also Modular manufacture design (Ernst, 2005).
However for the purposes of this paper, I will work with the first two only, since they are closely connected with the topic of product development and knowledge management, where the third deals with manufacture strategy and tactics.

All modular systems might be described as *"loosely coupled" (*Weick, 1976*).* This means that modularity involves independence between the particular modules of the system, and changes of one module will not affect design of any other modules. This independence is intentional. In computing, these might be described as systems, where the components use little or no knowledge of the definitions of other separate components. All they need, is the access to the visible rules and as long it is compatible with the architecture, they can work and improve their own product (component) – until they reach the physical technological constraints of the given architecture.

It is very important to note, that the term "*loosely coupled*" is strictly abstract. So for example a computer, even though the modules and all the components are tightly integrated and all are physically interconnected (and sometimes even touching each other) on the motherboard, we can say that all the modules are "loosely coupled" – as they are interchangeable (by substitutes) and thus create a platforms for "*economies of substitution*" (Garud and Kumaraswamy, 1993) - a range of component variations in order to configure a range of product variations.

For the reasons explained earlier, the modular product architecture is flexible – by substituting modules and using standardized interfaces between components enables variation. Particular modules, which over time become bottlenecks might be easily exchanged with more powerful and suitable ones. This "mixing and matching" provides the whole organization with strategic flexibility and creates potentially large number of product variations, distinctive functionalities, new features and/or performance levels (Sanchez, 1994).

Once the outputs of particular processes and components are clearly specified and explicitly announced, the design of these might be than partitioned into tasks, that can be performed autonomously and concurrently by loosely coupled organizations (von Hippel, 1990). The interfaces between the modules would be a building block for inter-firm or inter organizational communication channels for loosely coupled development process – so as long as the designers follow the design rules, the final product will be compatible with the rest.

This is in contrast with the traditional *tightly coupled organization* structure, coordinated by a managerial authority hierarchy - an organization design typically achieved within single firm. Within such a company, the engineering effort would follow methodology of constant optimization – and this tries to obtain the highest level of product performance within some cost constraint or the lowest cost for a product meeting a minimum performance constraint (Sanchez and Mahoney, 1996). Such a design typically leads to product designs, which are integrated, with "*tightly coupled component designs"* – so any change in one component would inevitably bring an necessary change to other components. For this reason, systems with such a structure would need much more extensive managerial coordination and care during any design processes. Moreover, the officer (or team of managers) in charge would have to have very extensive knowledge of most of the processes and components involved. In contrast, the modular organization can effectively eliminate a big deal of managerial and coordinatinal work by simply articulating what is the architecture about, and from this point the need for managerial coordination is lowered.

Therefore it save to say, that modular product design would inevitably lead to modular organization design – the organization of the network of companies, involved in the development of particular product or process would ultimately adapt the architecture of that given artifact – and they would be organized in very same way as are the components in the artifact.

2.2.3. Dominant Design

Both the theoretical studies as well as the empirical evidence support the premise, that the new technologies are not fully developed when entering the markets. The life of an technology is often characterized by a changing cycles of turbulent development, experimenting, learning – by- doing and subsequent reevaluation of the learned and its application.

When a new technology arrives to the market, there is a big deal of confusion. Even though there might be a good understanding and consensus on what the new technology ought to do, there is just a little agreement on what the major subsystems of the product should be, or how should they be connected – put together.

As the product architecture is non existent during this phase or in better case underdeveloped, the companies will experiment with different technologies and processes as they will try to put all the necessary subsystems they wish to incorporate into the new product together – and many concepts will occur during this period.
However, it is usual that only a small number of these concepts will survive on the market competition and those that survive will become the "dominant design".

According the Utterback's model (1994) there are 3 phases in every industry to set an Dominant Design. The first phase is the so called "*Fluid Phase*" – when a great number of technological solutions compete with each other. At this time, neither the problem nor the way the problem should be solved are very well defined and there is high variety of different solutions and approaches to the issue.

During the *Transition phase*, there is a quick elimination and shakeout of majority of ideas – and companies connected with these ideas as well – until the third and final phase – *the dominant design* emerges and only very few companies remain. As from now – since there s already and dominant design on the markets – the innovation effort would move from product innovation to process innovation. (Utterback, 1994)

"*It is (dominant design) equivalent to the general acceptance of particular product architecture and is characteristic of technical evolution in a very wide range of industries*." (Clark, 1985)

Also, the companies will starting from now on to try to figure out how can they differentiate their products from their competitor`s based on the same dominant design.

As an example, the emergence of the first car brought many different vehicle` concepts. During the experimentation period, there were different engines and propellant systems (electric, steam, gasoline etc., with steering wheels or tillers, with tires or without, wooden or metal wheels etc.). However, once the dominant design arises, the diversity is eliminated and only one concept will eventually prevail. For cars, it was the gasoline engine that provided the traction, but also had the concept of transmission connecting the wheels with the steering, particular chassis style etc. Simply put, the dominant design is a set of rules, that specifies arrange of basic choices about the design, which are not redesigned with every subsequent generation of the product. All the further improvement will take part on the component level, within the framework of the system (architecture). (Henderson and Clark, 1990)

As a consequence, the companies do not need to learn anything new about the competing architectures – since the prevailing architecture is the one of highest priority to them and they can easily turn to deepening their component knowledge.

2.2.4 Architectural innovation and Modularity Trap

From the incremental innovation standpoint, modular design has huge influence on the innovativeness of an organization. It allows the companies to focus on their own module and innovations inside this particular part. This is true as long, as the architecture of an artifact (and indirectly also the architecture of the manufacturing organization as seen before) remains intact and unchanged. In that way, the "*volume of Information*" (Ernst, 2004) is reduced and hence the amount of knowledge sharing, that is required for coordination is down as well. The burden of managerial coordination is lowered and these talents may be employed in other activities.

"When standardized interfaces in modular architectures are used to coordinate the product creation…processes, those processes can become self – managing. Both mid-level and senior managers can redirect much of their time and attention from routine tasks of monitoring, problem solving and intervention in those processes to refocus on essential tasks of strategic…goal setting" (Sanchez and Collins, 2001)

The companies can thus perform that activities, which have the higher value added and that are critical tasks for their undergoing ("*core competencies*"). Usually, these activities also generate the highest margins. The others activities where they cannot obtain high margins and which are not critical to their business would be simply outsourced.

This is what Langlois (2003)means with his statement, that modularity causes the "*visible hand of managerial coordination*" to vanish.
In his opinion, "*modularity reduces the need for management and integration to buffer uncertainty…and the buffering functions of the management are evolving to the mechanics of modularity and market*"(Langlois, 2003).

Both these arguments imply, that when considering modular design, the need of involvement required through corporate management is decreasing.

The important, but unanswered question is – what happens once the architecture changes, or begins to change?

The literature mentioned above does not work with such a possibility and simply ignore this option, where they present modularity as the ultimate modern management tool. However, as the experience goes, that architectural innovations are likely to happen in any industry, either once the old architecture reaches its technological zenith, or when the changes in the market simply knocks out the old architecture as outdated or not to the current customer`s need.

Architectural innovation is a solid challenge to all companies, even to those strongly integrated ones. This is due to the fact that it destroys the usefulness of the architectural knowledge for good, and since this sort of knowledge becomes embedded in the structure and information-processing of established organizations, this destruction is difficult to recognize and subsequently correct. Although the architectural innovation often does not bring any new technological advance, it involves new set of engineering and scientific principles and often opens completely new markets as well as potential applications.

As explained in the earlier chapters, the difference between product development of the whole system and of only its parts is great. Modular theory is more than suitable for the later, where no need of extensive coordination of development among modules in necessary. However, for the survival in the conditions of architectural innovation, an insight or better understanding of both is crucial for the company.

The architectural innovation is defined as "*the reconfiguration of existing product technologies" – "…the reconfiguration of an established system to link together existing components in a new way*" (Henderson and Clark, 1990) - in other words the architectural innovation re-shuffle the existing components, in a new and innovative way. This destroys the usefulness of the architectural knowledge, however – and this is very important - it preserves the usefulness of the knowledge about the components. And that is why it is so important, that any company should try to reach out and have deeper understanding of both sets of the knowledge, and not just blindly outsource to its suppliers without having better understanding of the components they employ.

Still, Henderson and Clark (1990) point out – that the sole components may not stay the same – untouched – by the innovation. Actually on a contrary, the architectural innovation is often triggered by a change in a single component – that will create new integrations and new linkages with other components. However, the "*core concept*" behind the each component – or the knowledge about it- it wouldn`t change that much, but rather evolve or adjust to the new system.

The reason why the companies fail to react to architectural innovations is, according to the authors due to the fact, that they concentrate too much on the development of their "core competencies" – which are based around the core knowledge of the component and its incremental development rather learning more about other possible architectures an developing this subset of learning capability as well as knowledge. (Henderson and Clark, 1990).

Therefore the challenge is twofold: first the company must be able to actually positively identify the threat as architectural innovation, and truly understand, that not mere changes in component, but the whole model of its product needs to be redesigned. This process might be painfully time consuming, as the primary reaction to new threat would in most cases be to just do some changes in number of components, rather rethinking the whole concept.

The second issue is the organization`s adaption to the new architecture. The challenge is quietly significant – an organization, which is stable and based on common SOPs and procedures based on the visible architecture, must change all these and become a true learning organization for the time being.
They must try to search for new solutions in ever changing environment – that's due to the fact, that the old dominant design is broken, however the new dominant design is not created yet and it is due to be set. This might be extremely difficult for old, huge and well established companies, who have rigid corporate structure. On the other hand, this might be much easier for new entrants or small companies – as it is much easier for them to change.

2.2.5 Architectural Change

The architectural innovation is very close connected with the *Innovation Trap* model of Chesbrough and Kusonoki (2001). According to their work, two ideal situations change during the time. The first is the "*integral phase*", which during the time will be substituted by the "*Modular Phase*". This, however is not the final end of times- through architectural innovation or technological changes, that go beyond single components, the circle might eventually close, and move back to *integral phase*, which might ultimately move again to *modular phase* and so on.
As we can see the general character of the technology is not static, and thus, once a technological change appears there must be alignment organizational change in order for the organization to survive. I explained this earlier – the organization of single organization to production networks will follow (copy) the technology alignment (either integral or modular).

Each of these periods is very specific, and brings its very own challenges and therefore the type of the organization structure is crucial. As during the modular phase - the modular organization structure, which favors virtual companies would be more appropriate. However, during the integral phase, such a organizational structure cannot accommodate the extensive need for development coordination – due to the fact, that market cannot accommodate for the technology development anymore and the companies must take care of the product development integrally.

"The overall model, therefore, is one in which phase shifts in the character of technology require an organization to reconfigure itself organizationally in order to effective develop technology." (Chesbrough and Kusunoki, 2001)

Once the new technology emerges, the technological development in the industry might often be described by the term "integral". As mentioned earlier, in such a situation, the interactions between the parts are not well defined and interactions between the elements are very poorly understood, as well as how different technological elements interact is unclear. At integral phase, the firms must learn and accumulate integral knowledge not only about the each new component, but also of the whole system and how the components should work together. But the integral knowledge is content specific and difficult to articulate in documents – it is tacit and usually learned by doing or experiencing (Nonaka and Takeuchi, 1995).
Therefore the company position itself closer to all the problems, and try to manage these issues through the involvement of its development teams in every area. They need to accumulate solid base of knowledge and they can only do so through a series of experiments, trial and error and continuous learning by doing. By going through this, the company can ultimately

understand how the technology works and thus can have greater chances to design new architecture. This is in contrary to the modular technology, where new components are simply plugged into the system (existing architecture) and communication based on the existing interfaces and standards. The modular technology counts on existing markets, which would facilitate the development and supply of suitable components. Such an market, however, is non-existent in the integral phase, since the communication between the supplier and customer is flawed – the customer has difficulties to specify the requirements of what kind of components they would need, as well as the supplier does not possess the understanding of the new architecture and might simply deliver parts, that would be useless in the new system. Moreover, each might try to force the counterpart to resolve the problems, which might bring subsequent difficulties. Therefore, once the architecture changes from modular to integral, "*to achieve close coordination and facilitate rapid mutual adjustment between pieces of interdependent technology, administrative coordination outside the market is required to develop a technology effectively*." (Chessbrough and Kusunoki, 2001)

What need to be noticed is – these two periods – Integral and Modular should be understood as ideals, or extreme situations. In reality, however, we would see a scale of situations which would blend these two periods into a semi modular or semi integral models. The shift between the integral and modular period is not immediate one neither – it rather is gradual, slow phasing from one model to the other one (e.g. from integral to modular – as the understanding of technical interdepencies is being better understood – the suppliers are therefore more ready to absorb the knowledge and deliver correct components to the customer).

Still, although the transition from integral to modular might be expressed as slow or gradual, the move from modular to integral is often very turbulent. This is the true danger of the modularity trap – the need for integral knowledge and firm`s unability to obtain this knowledge due to its existing managerial and organizational practice – its existing problem solving routines are simply no longer effective.

But once the technology is well understood and dominant design set, the standards will permit competition on the component level as well. This opens a completely new market and, more importantly, foster component innovation to completely next level – as it allows rival suppliers brings its own interchangeable products which would fit into the end product. Since they can adapt the economies of scale (as the component might be sold to a number of customers) this will also lower the prices to system customers. Under these circumstances, virtual firms will be more successful than companies that continue to manage these coordination activities integrally – as the advantage of the earlier information advantages within the firm are now insignificant in the light of standards. That is the reason, why the company must be prepared to adapt its organizational approach, in order to profit from their technology.

Table 3: The modularity trap

	Modular	Integral
Decentralized organization	Proper alignmentn Value realized only within technology layer No inefficient interactions	Misalignment Can`t manage interactions Insufficient instrastructure
Centralized organization	Misalignment Unnecessary internal coordination Reduced scale economies	Proper alignment Value realized in the system Effective coordination of undefined interactions

Source: Chessborough and Kusunoki, 2001

The table above shows the interaction between organization and technology – where the value can be captured or dissipated.

2.3 Architecture as a variable

As noted above, in modularity the greatest asset is the specific ability of building complex products or processes from smaller subsystems, which might be designed independently, but once put together still function as whole – as one system. In order for the system to work together, there must be set some set of rules, or schema, that all the particular components would follow in order to be compatible with each other. This schema is usually called architecture.

In his work, Ulrich (1995) did not only lay the groundwork for future research on modularity, but and also introduced terminology, which was later generally accepted in the field of architectural modularity research. His description of modularity and architecture in NPD is dynamic – he describes the process behind modularization – creation of modular systems. During this process he comprehends the architecture conceptualization, planning and mapping of the idea up to an explicit scheme of the product. This process has according to him 3 stages:

1. The arrangement of functional elements
2. The mapping from functional elements to physical components
3. The specification of interfaces among interacting physical components

Arrangement of functional elements is a pre- design conceptualization of "what should the project be capable of doing" or "what is its purpose". Ulrich is working with term *function structure* – whch might be used as a simplistic description or in some cases the system creators might even employ graphical expression of the products functional purpose.

He describes the whole concept of modularization at the example of a car trailer – its very basic *functional element* is "to expand cargo capacity". This is the basic function all car trailers have in common. Still, there might be variations in design between different functional elements –more detailed specifications of the product and one cargo trailer might have more or less functional elements than other – this all depends on the design approach selected by the creators. This is why two products at the most general level do the same thing, however might have different function structures when described at a more detailed level.

The second part is the actual *mapping from functional elements to physical components* – physical components implement the functional elements. Now the creators must choose the actual right physical components for those functional elements they identified in order to the system work effectively.

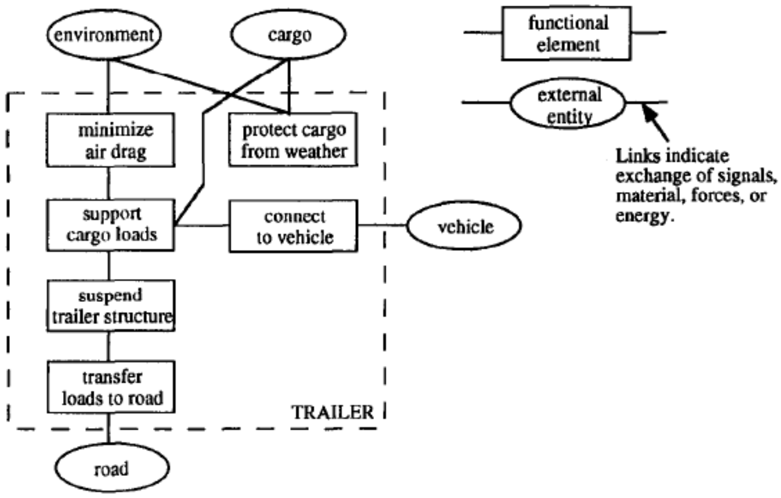


Fig. 1. A function structure for a trailer.

Source: Ulrich, 1995

Figure 4: Mapping Functional Elements

Lastly - *Interfaces* are very important part of every architecture. They are the connecting link between two or more components, and they have the unifying function. They might be both physical (e.g. wiring, geometric connections etc.) or non – contact (such as infra red connections). It is worth to note, that there might be different kinds of interfaces within one product. Also, as the industry develops, the companies might accept an industry wide interfaces for its components, so that they would be fully interchangeable and there would be no limitations regarding the manufacturer etc.

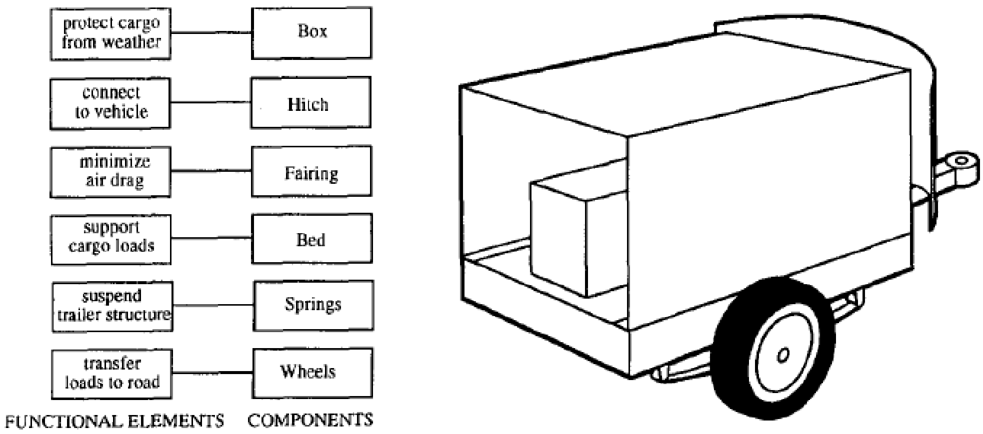


Fig. 2. A modular trailer architecture exhibiting a one-to-one mapping from functional elements to physical components.

Source: Ulrich, 1995

Figure 5: Modular trailer architecture

In the following part, I differentiate the New product development projects based on two variables. The first is the intended complexity of the product to be developed, and the second is the level of its relative newness- how innovative it is compared to the older generations.

2.3.1 Complexity

Differentiation and connectivity are two important drivers of that would determine the level of complexity – the more parts there are and the more interconnected they are, the higher the project complexity degree and vice versa.
The factors influencing architecture itself can be broken into two elements. The first is *differentiation* – which defines the number of varied components in the project (such as tasks, specialists, sub-systems, parts etc.). The second one is *interdependence* or *connectivity* – which defines the degree of linkages between the components. The constellation of these two contributes to the overall complexity of the architecture – deciding whether the product to be developed is of high complexity, complex or non-complex one.

The term product complexity, as a variable within the New Product Development area was first introduced by Clark and Fujimoto (1991) in their revolutionary study on NPD in the car industry. In their research, they rationalized product complexity as the number of body styles in the new car model. The reason they could do so was, that the body style for an car is driving factor of such an influence, that the number and variance of these styles would predetermine the physical style and design of all major components (engine, transmission, chassis) as well as all the possible linkages between these. This is what is described below as the "differentiation" and "connectivity".

2.3.1.1 Differentiation

Product complexity is an important factor that would greatly affect the manager`s decision. Often, the managers describe their projects as complex or simple. And all the tasks involved in the management of a project – such us planning, coordination, controls, goal determination, organizational form, project resources evaluation and project costs would be ultimately affected by the level of complexity of the given project.
The term complexity was first introduced by Baccarini (1996), who defined project complexity as "*consisting of many varied interrelated parts*". He explicitly lists out the total number of the varied components in the project (such as tasks, specialists, sub systems or parts) – he

introduce the term differentiation – with the meaning the more components the product has, the more complex its overall architecture will be.
So in simple words, Baccarini (1996)defines the complexity as the product differentiation – namely it is the number of varied components in the project (tasks, specialists, sub-systems, parts).

2.3.1.2 Connectivity

It is notable at this point to mention that the managers won`t usually interchange the term *big* with the term *complex* – there is a strong and widespread feeling that a “complex” project are more, than just the “big” ones (Williams, 1999). This is the reason we need to consider the connectivity (often called interdependence as well) at this point. Connectivity express the degree of inter-linkages between the groups of components – in other words what is the way these components are pooled and how do they operate together. Williams postulates, that in order to better understand the level of complexity, it is not enough to barely accept the existence of the interconnections between the artifact`s elements, but we also must study and define the nature of these connections.
Such, he defines 3 major groups of connection categories:

Pooled – in this situation, every element contributes to the overall project (or product) and they are irrespective to the other elements` of the system – their output is to the whole

Sequential – one element`s output is another element input

Reciprocal – each element output becomes other elements` input

The last group is the most tricky and difficult to manage. In situations like this – any change to the subsystem will generate changes throughout all the other sub-system and changes to every single component might be inevitable. This of course increase the necessity of extra allocation of resources to the project and more complex and careful project management will have to be employed as well.

2.3.2 Innovativeness

Innovativeness reflects the relative novelty of the product. During the New Product Development – the developing team is by the very definition of this term expected to incorporate some changes compared to previous products in order to gain some advantageous momentum on the market. Innovativeness describes the degree of this novelty – and this novelty might be many fold, starting from new products that the markets have never seen up to developing completely new and exciting technologies, that will see the light of the world for the very first time.
The source of the novelty might be variable – starting with customer requirement up to the strategy of envisioning new products based on expected needs customers might have. Be it any one of these, the innovative products would usually attract new markets, gain some sort of advantage compared with their actual competitors or even open new markets for the firm etc. Others might be reducing the manufacture costs, increasing quality or reliability and therefore increasing the awareness of the company brand and their products among the customers.

However, developing very innovative product brings some substantial risks as well as managerial considerations. Not only innovative products consume huge amount of development time, resources and often leads into great investments as well as staff`s commitments - whose immediate result is at best unknown. Also, with a very new product there might be some sort of chaos to the market and customer confusion, which could possibly destabilize the company`s position on the market.
The greatest risk however is as the level of newness grows - the increased difficulty to manage the New Product Development project successfully.

Therefore it is very important to analyze on the degree to which the project is innovative – as this will determine the level of effort that will be needed to allocate to the NPD project in order to be successful. In case the innovativeness is high, this would mean that the product to be developed is significantly different than the previous products developed by the company. If this were the case – the developers still don`t have the "best practice" and cannot be very sure whether the methods they wish to employ are the correct ones and would lead to the desired outcome etc.

I divide innovativeness into two main categories – the *product newness* and the *time to market* – both of these are introduced below.

2.3.2.1 Product newness

A very loose definition of product newness is that it represents the portion of the new product which has to be redesigned from previous generations of the same product.

Clark and Fujimoto (1991) were the first to introduce the product newness as a variable in the New Product Development and its relative influence on the success (or failure) of the poject. They represent product newness as the fraction of the *pioneering* (new) components in the vehicle (they studied the car industry) and the major changes in body process technologies. This was further developed by Wheelwright and Clark (1992) as the d*egree of change required in the product and/or process technologies*. The product newness variable has an direct link to the complexity of the project – since the more features are about to be added and thus the more components need to be redesigned, the greater the complexity of the overall product will be. Several research papers (Clark and Fujimoto, 1991; Swink 1999, Barnett and Clark, 1999) came to conclusion, that the increased product newness will have exponential increase in the number of tasks to be done to finish the project. This means, that the amount of engineering hours, time to market will be on growth as the product newness increases, and thus there will be need to increase the costs of the NPD.

One of the most influential study in the area of product newness was report by Booz, Allen and Hamilton (1982), who developed matrix where the level of analysis was relative product newness was related to the company or to the market dimension. On the basis of these two variables, they introduce six different classes of new products:

- **New to the world products** (first of their kind, creating an entire market)
- **New product lines** (established products that are new to the company)
- **Additions to the existing product lines** (established products new to the firm that fit into the firm`s existing product lines)
- **Improvements and revisions to existing products**
- **Repositioning**
- **New applications for existing products** (i.e. existing products retargeted to new market segment)

As we can see – they don`t only consider the technology dimension in their analysis, but also add the company considerations and most importantly the market impact of developing such a product. The fusion of all of these variables would show us complete picture of the overall product innovativeness and will be the most suitable tool to asses all the risks connected with the development of the new product.

2.3.2.2 Time to Market

Time to market is one of the most important factors in the successful New product development. The delayed launch means loss of market and potential profitability. However, the increased cost of new product development – connected with allocating more resources and menpower to the project so that it can be finished faster will ultimately lead in increased cost, which does not add to the competitive advantage of the final product.

The worst case scenario is that not enough planning is done before the development, leading in ill defined procedures and targets. Once they realize that something is wrong or even missing – will lead into rushing on the last minute in order to redesigning, which would substantially increase the total costs.

Measuring time to market is extremely difficult, as every company would set different standards for both the project start, kick-off and end.

2.4 Literature review summary

In the chapter two we discussed the problematic of supplier-buyer relationships and the factors that affect them, we also opened the issue of modular production network and modular design as well as the considerations connected with the product architecture.

Since the literature review is an important part of this thesis, and based on it I will create the research framework it is a good time now to provide the reader with an short summary overview of the sources I intend to utilize for the conceptualization of the research framework and further research with the business practitioners.
After the literature review, two major areas of study emerged: *The architecture as a variable* and the *Buyer-supplier relationship and NPD*. In the following body, I shortly review the major points to create conceptual constructs for each of these two areas.

2.4.1 Product architecture as a variable

In this part of the study, I will concentrate on the structure of the products to be developed. The selected works are important, since there is a link between the architecture of the product to be developed and the way the companies will manage their new product development. So to have this part better cleared, I divide it into two categories with two subcategories each. The categories are *complexity* and *Innovativeness.*

Complexity

When it comes to the first category, complexity, I decided to include the Differentiation as introduced by Boccarini (1996) as well as the connectivity (Williams, 1999). This will not only show us how big the project is, but will also give us an explanation on the inter-linkages between all the parts within the product.

- Differentiation - number of parts (Baccarini, 1996)
- Degree of linkages between components (Williams, 1999)

Innovativeness

The second category of Innovativeness gives us an idea on how much does the product change from one generation to the other. Any change indeed brings some substantial risk that will increase the complexity.

- Degree of change between 2 generations of the product (Wheelwright and Clark, 1992)
- Product newness matrix (Booz, Allen and Hamilton, 1982)
- Time to market

2.4.2 Buyer supplier relationship and NPD

In this part I will concentrate on the importance of the relationship between the companies and suppliers to be selected. The selected theories are important and will put some light on the procedures and considerations when selecting new suppliers to involve them in any generic new product development. In the later part of this thesis, I will employ and analogy on the data obtained in this way and to deduct the companies behavior under the architectural innovation.

To make this point more clear, I divide this section into 3 parts: *Supplier selection*, *Time frame of the supplier involvement* and *Development responsibility and scope*.

Supplier selection

To be able to find out *how* organizations award the right suppliers with their projects and to better understand what is the rationale behind this selection, objectives from the following sources will be utilized:

- Supplier segmentation and output specificity (Dyer, 1996)
- Four Supplier roles in Product development (Kamath and Liker, 1994)
- Reasons to involve suppliers and the Dependence on knowledge (Fine and Whitney, 1996)
- Suppliers importance and influence over the final design (Kamath and Liker, 1994; Sturgeon, 2002)

From the studies starting with by Dyer (1996), Clark and Fujimoto (1991), Kamath and Liker 1994) up to Sturgeon (2002) we can see that the buying companies tend to manage their pool of suppliers based on a certain criteria and considerations. In order to ease their procurement consideration, they often divide these into groupings based on the perception of how they see their suppliers. Studies by Dyer (1998, 2002) show that suppliers should be segmented based on the specificity of outputs they manufacture and it will be the specificity (the level of strategic importance) of the output that will influence the type of relationship the buying company should develop with them (*arm-length* and *partnership relationships*). It is Kamath and Liker who extend this model by the supplier`s technical development and manufacture capability. They come up with four specific supplier roles, that are differentiated on the level of knowledge the supplier posses in the particular area of expertise to point out and differentiate the level and scope of project such a supplier is capable to successfully finalize. The most important suppliers might actually accumulate such an volume of useful information that they will be given the responsibility to develop whole subsystems by themselves and thus greatly influence the overall design of the end product.

The research of Bidault et al (1998) and Ragatz (1997) list quite a number of reasons on why to integrate the suppliers into the NPD - lowering development times, improving the quality or lowering the costs be just few. Nevertheless all these examples being important, it is Fine and Whitney (1996) and their model of *knowledge dependence* that will be the driver of the supplier selection – the buyer will be dependent only on those suppliers with some very specific and rare knowledge.

Time frame of supplier involvement

To be able to better understand *when* will companies start to consider to involve the suppliers and to get a better idea on the rationale behind these considerations, objectives from the following sources will be utilized:

- ESI - Early supplier involvement (Monczka et al, 1999)

In this paper I do employ the framework of Monczka et al when considering the time frame of the supplier involvement. They show that the suppliers should be invited during the concept phase at latest. This is supported by other research papers introduced earlier (Ragatz et al, 1997; Bozdogan et al, 1998) that do suggest to introduce suppliers as early as possible into the NPD.

Kamath and Liker (1994) show, that this consideration might actually differ from between supplier role to role, based on the specificity of the supplier –the most important suppliers with critical assets (such as Partners) might be invited very early, where some less important roles later.

Development responsibility and scope

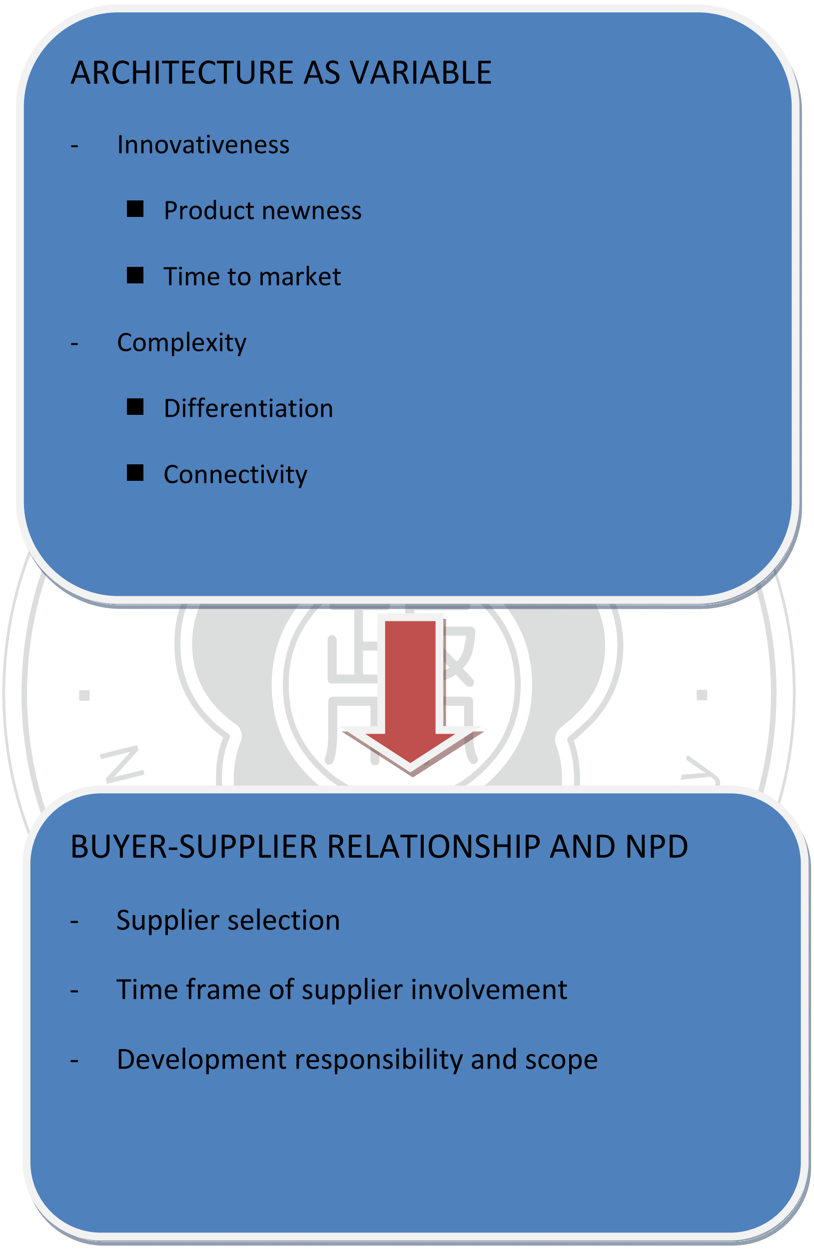
To be able to find out how organizations analyze and match the suppliers with the correct cooperation pattern for information sharing and managerial alignment, objectives from the following sources will be utilized:

- Usage of functional teams (Dowashahi, 1998; Hendfield et al, 1999)
- Management alignment matrix (Olson et al, 1995)
- Top Management commitment (Monczka et al, 1999)
- Knowledge partitioning (Takeishi, 1998)

The important implication of Olson`s research is, that the way suppliers should be involved in the New Product Development is not always the same. On contrary, he argues that the pattern of cooperation will be affected by the level of need for information sharing and its speed. In some cases, the high level of information sharing might actually be a constraint for the development, as the long and extensive discussion necessary might be too much a brake for a fast cycles of some industries with only very low product change. Therefore the functional teams as and top management guidance introduced by Monczka et al. (1999) or Dowashahi et al (1999) might be not necessary in some cases as simply too expensive and slow for that task. Takeishi`s concept (1998)is important one, as it introduces the idea that "companies should know more than they manufacture". In a successful NPD, all the parts should be able to swiftly and clearly communicate and therefore some sort of mutual understanding on each other`s technologies and knowledge is crucial.

Chapter 3 – Research design

3.1 The research framework



Source: This research paper

Figure 6: Research framework

Table 4: Research framework definition – Architecture as a variable

INNOVATIVENESS	**Product Newness**	The proportion of how much needs to be developed on the new product compared to the old generation of the same product
	Time to Market	How long does have the team have from concept to deliver the product to the market
COMPLEXITY	**Differentiation**	How many parts (components) the product have?
	Connectivity	What is the relation between the components? In what way are they connected?

Source: This research paper

Table 5: Research framework definition – Buyer- supplier relationship and NPD

SUPPLIER SELECTION	**Supplier segmentation**	Are all suppliers equal or does the buyer create criteria based groups for different suppliers?
	Supplier roles	What are the roles supplier give to their suppliers? Is there any relationship between supplier and buyer?
	Reasons why involve supplier	What are the major reasons to invite supplier into new product development?
	Goal setting and planning	What is supplier`s influence on the architecture design of the new product to be developed?
TIME FRAME OF SUPPLIER INVOLVEMENT		When are suppliers first involved into new product development? Is this same for all roles (if any)?
DEVELOPMENT RESPONSIBILITY AND SCOPE	**Management alignment and involvement**	What is the pattern of inter-company cooperation? How are the teams interconnected? Who has the ownership and what is the role of management?
	Degree of knowledge sharing	Do suppliers/buyers share component/architecture knowledge?

Source: this research paper

3.2 Research Method

The research approach is often either *quantitative* or *qualitative*. Both do have strengths and weaknesses and none can be put over the other as the better one. The best research method is situation based and depends on the circumstances of the study and the study`s research purpose and accompanying research questions (Yin, 1994).

Qualitative research is supposed to investigate, interpret, and understanding the phenomena by the means of inside perspective (Patel & Telebius, 1987).Also, Yin mentiones, that qualitative research is often connected with case studies as a chariot to better understand the of the research problem and its consequences.

Quantitative research is quest for knowledge that will measure, describe and explain the phenomena of our reality (Patel & Telebius, 1987). As such, it is very often connected with natural science mode of research, data is quantitative, obtained from samples and observations seeking for relationships and patterns that can be further expressed in numbers and patterns

In this research paper I use the case study approach to study the relationships between the companies that have the great influence on information sharing and trust building between the firms in the industry. Although other research methods might be more accurate in the data collection and analysis, but won`t be that comprehensive in explanations of the processes behind this data. This is supported by Yin (1994), who defines case study as:

3.3.1 Research strategy

According to Yin (1994), there are five primary research strategies on how to collect and classify data in the social sciences – these are *experiments, surveys, archival analysis, histories* and *case studies*. Every single strategy is more suitable than the other one depending on three conditions:

-The type of research question posed
-The extent of control an investigator has over actual behavioral events
-The degree of focus on contemporary as opposed to historical, events

Table 6: Situations for different research strategies

Research strategy	Form of research question	Requires control over behavioral events	Focus on Contemporary events
Experiment	How/Why	Yes	Yes
Survey	Who/What/Where/How many/ How much	No	Yes
Archival/Analysis	Who/What/Where/How many/ How much	No	Yes/No
History	How/Why	No	No
Case study	How/Why	No	Yes

Source: Yin, 1994, pp 6.

The purpose of this paper is to gain better understanding on how buyers do proceed during the NPD so that I can articulate suggestions to suppliers on how to adjust their strategies. Therefore I do not need control over *behavioral events* – and therefore the *experiment* as a research strategy is out of consideration. *Survey* and *analysis of archival records* is about to be used when we want to describe the incident or prevelance of phenomenon or when we want to be predictive about certain outcomes – and this is not the case. In addition, I want to see how the companies manage their relationships and how these relationships influence their business strategies – this means that *historical* strategy is not appropriate neither. (Yin, 1994)
This leaves me with the *case study* as the only feasible research strategy for this paper.

A researcher can choose between single case study and multiple- case study. I employ the multiple-case design where I replicate the same logic for each case studied - in order to have stronger evidence to support my findings and also to study various approaches in the industry to the problem. Also, if any similar patterns of behavior are found during the analysis, this will support the robustness of the evidence from the literature review and point out what is the standard procedure in the industry in the case of Taiwan and will allow me to articulate an generalization of the findings.

I use the explanatory category of the case study qualification (Yin, 1994) to analyze similar patterns (pattern-matching) that might let to us to find and articulate possible solutions to the problem studied. .

3.3.2 Data collection method

According to Yin (1994), there are six sources that can be found as the source of data collection for case studies. These are: *documentation, archival records, interviews, direct observations, participant observation*, and *physical artifacts*.

Table 7: Sources of Evidence

Source of evidence	Description
Documentation	There are various types of documents, eg.: statistics, official publications, letters, diaries, newspaper, journals, branch literature, brochures etc. Documents are mostly used for collection of secondary data
Archival Records	E.g. service records, organizational records, maps and charts, survey data and personal data. Often used in computerized form, also for secondary data
Interviews	Often take form of *open-ended nature*, in which investigator can ask respondents for facts of a matter as well as for respondents opinions about events. Other option is *focused* interview where respondent is interviewed for short period of time (e.g. an hour). Also, the interview can entail more structured questions along the line of *survey.*
Direct observation	This can involve observation of meetings, sidewalk activities, shadowing, factory work etc. Observation often provides additional evidence and information about the topic studied. Often there is more than one observer to increase the validity of the observation
Participant-observation	Special case of observation, when the participant takes active role in the incident observed.
Physical Artifacts	Technological device, tool or cultural artifact, work of art etc.

Source: Yin, 1994, pp. 85

Since I conduct a qualitative study, therefore *archival* records are ruled out. *Direct observations* and *participant observations* can`t be employed neither – their financial and time demands are simply beyond my possible resources. Although I study the specifics of Taiwan IT industry, I don`t need any special insights into the local culture for the purpose of this study – and therefore I don't choose the *Physical artifacts* as a source of evidence. I also don`t expect to reverse-engineer any of the components studied.
This leaves me with only two sources of evidence *interviews* and *documentation*.
According to Patel and Davidson (1994), there are three kinds of question methods: *questionnaires*, *telephone interviews* and *personal interviews*. I used all three of them. First, based on the literature studied I prepared a questionnaire that will help me to keep my interview structured and well organized. Than I conduct *personal interviews* with those respondents, whose time availability allowed so. In cases when the distance or time frame were a constraint, I employed the *phone interview*. Before every interview, the respondents were briefly instructed about the purpose of the interview to make sure that they are a suitable company/respondent.

3.3 Sample selection

All the companies were selected based on the same logical construct. The major prerequisite for the selection process was the companies to be deeply embedded within the supply chain of Taiwan IT industry.

Also, companies that have experience with integrating components that were not developed and designed by themselves only into their new products can be considered only. They had to work on the development with suppliers and in order to consider them to qualify, they have to do so repeatedly in so that they have better understanding and clearly shaped procedures as well as routines in doing so.

This will show us possible patterns of how would s company react on new technologies they never worked with before and what would be their management reaction on how to deal with situations like architectural innovation.

This research is about to demonstrate us possible methods on how can companies overcome the uncertainty that is involved in the development of completely new products, based on very new architectural configuration.

When thinking about how can the management take grasp of such a challenge, we should consider two most basic elements of the architecture and its change:

1) What is the time frame of the change to occur - and thus how much time would be the team given to come up with a new solution? Is there more time or they need to come up with a solution fast, sacrificing others?
2) What is the overall complexity of the product to be developed? Can the new product architecture of the product to be developed be purely modular? Or does the developing team has to choose more integral one in order to increase the efficiency and/or the lower the risk of being copied by the competitors?

Based on these two considerations, I created a conceptual matrix that helped me to divide the products of the IT industry into 4 major groups and then contacted number of representative company from every single group to research. Based on these criteria, I had quite clear idea on what companies to contact for what products and for doing so I used the extensive network of NCCU TIM and NCCU EMBA alumni network to target the most suitable candidates. All of these candidates were first contacted via email to introduce the scope of my research to them as well as to conduct a simple pre survey questionnaire to make sure I target the right people with the best insights as well as past experience from the industry.

Some of the alumni were unfortunately very busy to participate or had to refuse to participate on the interview due to reasons connected with NDA`s, however even though were this the case, all of them were very kind and highly supportive.

Table 8: The architecture matrix

	High innovative products	Low innovative products
Highly complex products	Tables, Notebooks, Cloud Computers	Supercomputers, PCB, Smartphone
Low complex products	Flash card, LCD Display, Cooling device	CD/DVD Rom, GPS, Peripheries

Source: this research paper

3.4 Data collection

This research is based on the analysis of interviews I made with four Taiwan based companies IT companies. But before I can conduct the interviews with the counterparts from the business, I had to undergo an extensive study of literature to gain better understanding of the complex situation my counterparts are dealing with. This also helped me to create an conceptual model for this thesis and decide on what would be the best candidates for the interviews.
Apart from the interviews, I also studied materials that helped me to get better understanding on what kind of situation do the companies face (such as internet news articles, sales brochures and their dedicated web pages and technology reviews).

3.4.1 Primary data

The data I valued the most for this research came from my face to face interviews with the business practitioners, who have to deal with the issues I describe in this thesis on a daily basis – and they are the most qualified to provide us with real insights on the industry standards as well as best practices. The companies and interviewee`s are in the table 2 as seen below. Please note that some interviewee`s names as well as companies names were changed due to confidentiality issues.

Table 9: Companies studied

Company name	Interviewee	Interview place
ASUS	Mr.S.Y. Shian, corporate vice president and general manager of the notebook unit	Phone interview
ADVANSUS	Mr. Charles Chang, Director at Advansus	ADVANSUS HQ building Ruiguang Rd
SANAV	Mr.Thomas Chen, Chairman	SANAV HQ Building, Tucheng
Thermal Management Company	Mr. Qin, Product Marketing HQ	Phone Interview

Source: This research paper

3.4.2 Secondary data

The main reason I employed the secondary data was to get better understanding of the cases as well as theories I am working with as well as to organize the output I received after the interviews.

The main sources were: internet web pages of studied companies, their sales materials, technology reviews, news and newsletters etc.

Chapter 4 – Case presentment

4.1 Case background - ASUS

Asus was founded in 1989 in Taipei, Taiwan by four former computer engineers from Acer. In merely 20 years, ASUS became one of the world leading PC companies, with a broad portfolio of products and product families, including their premier motherboard series, innovative notebooks and netbooks as well as tablets, mobile devices, servers or networking solutions etc.

The innovation was always at core for ASUS, with more than 1/3 of the total global staff in its R&D. The quality is another area of Asus` expertise – allowing Asus to win more than 3000 awards in 2010 only.

Being a true system integrator of cutting edge components into new concepts and products, Asus revolutionized the PC industry in number of aspects and areas – but the most visible example is the EEE PC, first introduced in late 2007 as well as the SSD hard drive, which later became the new standard for hard drives across the industry.

I studied the notebook division of Asus, which is also responsible for development of the new tablets introduced into the product family as well as the hybrid product between these two – the Transformer PC.

Asus is so called system integrator – which means they integrate scale of components into their end products. This involves and tremendous amount of component knowledge necessary, as well as great understanding of the direction of the end-user preferences and market trends. As such, Asus engineers must often communicate with both marketing departments and have good understanding of the market situation on one side, and than talk to their component suppliers on new specifications and work together on the component on the other side. Only in this way the suppliers can provide with new innovative components which are necessary in order to bring new, innovative products.

4.1.1 - Architecture

Notebooks and computers in general are very complex. These are the products, which consist of hundreds of components connected together so they can execute a great number of operations and use.
Hawlett and Packard define 15 major component groups, and each of them is further divide on further subgroups. Wikipedia specifies ten most critical components of the personal computer. This gives us scale of several hundred components within the frame of the computer that must be carefully coordinated so the whole will work.
The typical components are the CPU, memory (RAM), power supply and battery, video display controller, display, removable media drives, internal storage (Hard drive), input (touchpad, mouse etc.), cooling etc. The motherboard is the centralizing unit which utilizes all the communication of the components and therefore plays a vital role in every computer.

Source: www.hp.com

Figure 7: PC/Laptop components conceptualization

When developing a new product, the developers need to consider all of these components and each ones particular impact on the final product. This is so since the PC industry is extremely competitive and apart from small number of IT companies, which can enjoy their competitive advantage originating from the software differentiation, most of the companies competitive advantage is obtained through hardware innovation and branding. Both of these are directly affected by the composition and careful selection of the components to be inside the product. Also, since Asus is an system integrator – they would mostly employ innovation of others (their suppliers) to incorporate it within their system and bring it to the market.

The components linkage pattern (connectivity) within the Notebooks can be identified as the reciprocal - since computers are interactive systems and most if not all of these components are interconnected and interlinked. In this way, each elements output may become each element`s input. This bring us into situation with high level of differentiation as well as connectivity – a clear condition for very complex products.

4.1.2 - Innovativeness

4.1.2.1 - Product Newness

The innovativeness of the notebook computers is moderate to rather high. There is quite substantial number of components (such as CPU, HDD, display, memory) that are subject to regular change – such as the Moore`s Law etc, that would affect the overall innovativeness of the product as defined by Wheelwright and Clark.
Also, we can identify a large group of innovative new products that emerged I the PC industry in recent years – be it the EEE PC, which might be identified as the New to the world product, established product lines – such as the new Asus Transformer, which plans to tackle on the tablet market or the new additions to the existing product lines – be it the new smartphones, gaming notebooks etc.

4.1.2.2 - Time to Market

Time to market in the PC industry is ridiculously fast, with development times from concept to manufacture within one year. Today the designers are literally developing products that will be marketed one year after, so that they can stay competitive and on the tip of the peloton. This requires some good background on the product vision as well as great market reading and analysis.
On the other hand, in case the company did not register the competitive or breakthrough project, they still might have the chance to throw an “me too” product on the market within less than a year from the competitor`s announcement – thanks to the help and support of suppliers. This was the case of EEE PC, where every major PC company was able to introduce its own netbook within a very short time from ASUS`s introduction of EEE PC.

4.1.2 Buyer-supplier relationship in NPD

4.1.2.1– Segmentation of suppliers and vendor management

Asus` products can be described as the highly innovative and high complex as well. For this reason, they must be open to new technologies and ideas from outside as well, and in cases when there is no existing component on hand – simply co-develop it using the supplier`s existing knowledge. This is very essential approach to foster the architectural innovation – change the configuration of existing components as well as develop or change those components that are critical for the new products.

In this way – they try to create some sort of business relationship, which is partially codified - based on business deals and partially trust based.[4]

However, not every supplier is fit to work with Asus, and the company would be selective in who can work with them on the new product. In general, they have two tools to use to differentiate the suppliers – one is more long term, where the other is immediate one. In the most lose sense – they would divide the supplier based on their technology attractiveness – and to what extent the supplier can transform the knowledge into what Asus wants them to deliver. This corresponds with Kraljic`s findings, where companies divide suppliers based on relative component commodity value.
For every critical component group, they would have a specialized engineer in their central R&D unit – so called "New Product Engineer" – who is knowledgeable about every major vendor from his sphere of responsibility. In this way, they can create so called technology bookshelves (Monczka et al) to keep track of attractive technologies outside the company.

Once they are about to choose who is eligible for the cooperation – they would use other considerations as well – where they have five most important factors:

- Quality
- Cost
- Delivery
- Technology
- Service

[4] They would sign non-disclosure agreements with the providers, as well as create business deal where they specify the scope, volumes of expected orders as well as exclusivity on the technology. This would reduce the risk of the supplier in giving away some of their precious knowledge and be more willing to participate. In the interview, however, it was mentioned, that there are some soft mechanisms as well – e.g. the supplier would provide with an major discount on the surplus parts, instead selling them for premium – as an investment into the future relationship and next projects.

4.1.2.2 Supplier roles

Based on these indicators, they can divide the suppliers into different roles. It is obvious, that the suppliers are not all equal. On the other side, suppliers of strategic components, who can deliver specific solutions are perceived much more higher on the value chain than suppliers of non-strategic, commodity based components. To reflect the importance of such an relationship- Asus would do only system-based testing of the components from the strategic suppliers – testing of component`s performance inside the system. For the component specific testing, they would completely trust the supplier and won`t do their own testing as long, until they have a serious suspicion that the component might be defective.

4.1.2.3 Goal setting and influence over planning

During the New Product Development – Asus would always first try to employ the existing components for the new product. Often, however they are faced with the trade off between use existing versus develop new, more suitable component. To deliver the vision to the market, they often have to choose the later part – and as they are mostly system integrator, who lack of deep component knowledge – they would have to rely on the supplier to provide the market with the cutting edge innovation.

As Mr. Shian mentioned during the interview: We would listen to their suggestions. Absolutely. This is co-working environment. We have the knowledge of what we want, but they have the knowledge of how to build it. So often its tradeoff between these two.

This means, that the supplier can actually have quite an impact on the final design of the product. Asus is a system coordinator, and if they believe that the option suggested by the supplier is better, they would go and redesign the architecture in the favor of such a change – so there are possibilities about the final specs and these might be affected in the supplier`s favor. Once these specs are set, there are not ay ways of how to change the major points. This is important so the component would not interfere with any others and would communicate within the interface properly. However, the suppliers are still quite free to do minor changes in their design if they think that can be of any benefit – as long as the changes don`t jeopardize the project as whole

4.1.3- Timing

The consideration when to involve supplier into new product development is very crucial one – as an early introduction of supplier who is not fit might create great slow down in development, whereas late introduction of important and knowledgeable supplier might bring need for redesigning and subsequent retooling.

For the non strategic suppliers – Asus would only provide specs during the prototype stage and ask for the components they need at that time to do the overall testing.
This might be also the case of strategic partners, however without any innovative product for this project. On the other hand, those suppliers, whose input is necessary would be invited as soon as possible – usually during the product planning phase, just after the vision is created and approved by the top management. However, there are often preliminary discussions on the technology with the supplier even before that – so that Asus can work on their feasibility studies and have some more solid data to work with. This is also the time, when the suppliers are free to suggest any possible solutions and changes into the design – since their understanding of the technology is much deeper than Asus`.

4.1.4 Development responsibility and development scope

4.1.4.1 Managerial alignment

In Asus, the top management is directly involved in the project development. Looking at their company background – this is understandable, with some great electrical engineers in the top management and chair.

The management is involved from the very beginning – and every projects future is connected with the ability of the development team to sell the idea to management. The strategic suppliers play an important role in this – as they need to provide the Asus central R&D team with solid information on the technologies as well as on what is possible to do in the short development cycles of the PC industry, and what is not possible.

This is also where the targets of the shared development are created and communicated. Both supplier and Asus will agree on the targets, and these will be given to the top management for authorization. These management approval are more of strategic level – general directions on what the product should do, and they would give only a very vague general specifications on what they expect. The Asus development team than has quite free hands to work on the specifications with the vendor. Usually, they would provide the supplier with lot of space to show many possible solutions where only the main guidelines are the limits. If the suppliers is within these guidelines, than he has a lot of freedom for change.[5] Such an approach is, however, typical in regard to the group of strategic suppliers. In case of non-strategic or commodity suppliers, much less freedom is given and more rigid rules would apply.

On the other hand, the top managers of Asus and suppliers would not meet and discuss the new projects, instead, they would provide support to their own development teams in number of ways, such as meetings, envisioning etc. The rationale here is, that for more innovative projects they wish to attract suppliers with similar way of thinking as is theirs. Than the intercompany link is much easier to spark.

As Mr. Shian put it: This is art of negotiations, In PC industry, if you are number one vendor to provide with some new or more features to your customer, you have better advantage. So I think basically Asus have the image we want to provide some kind of innovation product to the market, so the most competent vendors would know that Asus is quite focused on do our best to provide innovation. So they are quite willing to provide the new features to market. I think this kind of image – is important to Asus. If we did not have this kind of record, it would be much more difficult to find vendors who were willing to innovate with us.

The contact between suppliers is mostly managed by Asus`s dedicated engineers and dedicated teams respectively. These will exchange the data in the form of CAD files, emails, prototypes etc. Also, there are common visits to each other`s plant, as well as visiting engineers in case of more critical and urgent component designs. For more complicated components or components, where the design changes would interfere with the overall product design and therefore changes in other parts would be necessary they would create a special team under the central R&D unit.

These teams usually have some specialty in the component, as well have rather good understanding of the overall system design – they posses good component knowledge as well as decent architectural knowledge. In this way they can filter the information necessary and

[5] During the development of the new Transformer Tablet PC, Asus had to co-develop new display. Since the marketing envisioned this product to be usable outside the house, on the direct sun as well, these displays had to be quite bright. Therefore one of the major specs given provided by the management was a limit to the lowest brightness as well as system of brightness settings. After discussion with the supplier, they decided for the IPS display technology as it was the most promising considering the usage. This was rather complex task, since the display will interfere into the design of other parts as well – the battery, casing etc. Still, they would provide only the rough specifications to the supplier – size, connection as well as the minimum brightness required – and give them the freedom to choose their own approach the target of the project – such as add ore LED or increase the transparence of the frontal glass etc.

work as an liaison between the supplier and the central R&D. They would simply know what each needs to know and filter the information playing the role of an gatekeeper – so that neither is overwhelmed with unnecessary information.

4.2 Case background - ADVANSUS

Advansus Corp. was established in January 2006 as a joint venture between ASUSTeK and Advantech based on the strategic alliance agreement signed in September 2005.

The main scope of company operations is to provide both of the partners as well as their growing body of customers with the industrial computing and Design and Manufacturing Services (DMS).
The main idea was to have an platform, where both companies can share their industry talent to work on tailor made solutions and still keeping the costs low. This proved to be a successful move for both of the companies, where Advansus is working hard to become the industry global leader in its market niche.

Advansus has quite an unique position in the value chain, where we can see them an as both an imported and skilful supplier as well as an demanding customer to the suppliers of the components they employ in their solutions. They often end to be very knowledgeable of both their suppliers and customers needs so that they can provide with the tailor made solutions tat are necessary.
They are in so called "embedded systems", which means they do design computer subsystems that do control functions within a larger system, It is embedded as a part of a complete device, often including hardware and mechanical parts – embedded are dedicated to control and handle particular tasks.

In general, embedded systems have 3 main characteristics[6]:

1) They are designed to do some specific task, rather than general purpose computers for multiple tasks. Also, they usually have real-time constraints that must be met (safety, usability, performance etc).
2) Embedded systems are not always stand alone devices – often they are small computerized parts within larger device that serves more general purpose (e.g. motherboard within PC)
3) The program instructions written for embedded are referred as firmware and are stored in read only read only memory flash chips. They run very limited computer resources (little memory, small/no keyboard and screen etc.)

It is common that engineers would optimize these systems to reduce the size and cost or increase reliability and performance based on the customers need. To do so they will need to

[6] http://en.wikipedia.org/wiki/Embedded_system

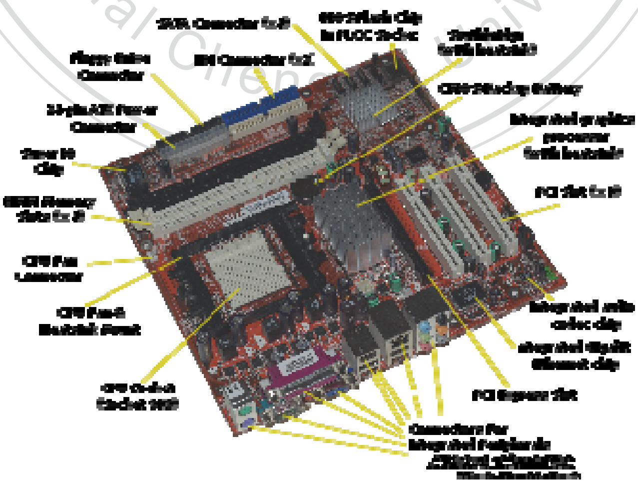
have a complete knowledge of the components they employ on hand or extensive connections with their supplies. Also, the odds that they will work on something completely new with their suppliers are quite high. Therefore ADVANSUS is an good case to study the supplier-buyer integration.

Sometimes they do employ the economies of scale, however usually they are working with smaller numbers and they aim their strengths on better customer satisfaction in niche markets.

4.2.1 Architecture

4.2.1.1 Differentiation

Advansus` products all utilize a great number of components. Motherboards, as an example – which is one of their flagship product and major source of their revenue – consists of 7 crucial areas of components at minimum. These are the sockets(or slots) to install the microprocessors, slots for memory, chipset which will form the interface between the CPU`s front side bus, main memory and peripheral buses, non-volatile memory (such as Flash ROM or BIOS), a clock generator to synchronize the various parts of the system , slot expansion cards and finally the power supply. Also, nearly every motherboard will include connectors to communicate with input devices such as keyboard and mouse. Each of the categories mentioned above is not final, but rather a component group which will only increase the total number of components in the system.



Source: www.wikipedia.org/wiki/motherboard

Figure 8: Motherboard components conceptualization

4.2.1.2 - Connectivity

All these components are deeply interconnected – connection is the raison d`etre of the motherboard – to provide the electrical communication with the other components use to communicate. Therefore a deep knowledge about the components is usually necessary. This suggests, that the connection alignment is the reciprocal one – where ever element`s output is other element`s input.

4.2.2 – Innovativeness

4.2.2.1 Product newness

Although the components that the motherboards utilize are subject to constant change, there is not any critical innovation necessary within the motherboard industry. The typical innovation would happen within the switching arena (e.g. mixing the 3D video cards) – utilizing components from different vendors or different models to coexists within one computer and thus increase its computing power, connectivity or power saving innovations etc. Considering the Wheelwrigt and Clark concept, these findings does not suggest high innovativeness, nor the Booz, Allen & Hamilton one does. Most commonly we are seeing Improvement sand revisions of existing products – incremental innovations that build on the success of the previous research within the industry and technology.

4.2.2.2 Time to Market

The time to market issue might differ dramatically. There are several projects which take less than a year from the pre-concept up to the marketing. These are most commonly the market extensions and additions to the existing lines. There are, however projects with longer time to market – these are usually projects of merely research importance whose immediate chance of introduction to the market is rather low. There projects usually take into consideration the medium to long term technology strategy of the company and are the link of the company to the future – to make sure they will stay competitive on the markets in the future as well and will possess the important technologies to do so.

4.2.3 Buyer-supplier relationship in NPD

4.2.3.1 - Supplier selection

Advansus` position in the supply chain is little different from the other two companies studied – as an ODM they are both component supplier and customer, depending the angle of view we employ. This offers us a great opportunity to explore the problematic from both points of views. Still, Mr. Chang, who was kind enough to do interview with me mentioned, that the general principle stay the same and differences would be in only details of merely tactical substance.

4.2.3.2 Segmentation of suppliers and vendor management

In general, they divide their suppliers on strategic and non-strategic suppliers. This division is based on the scare rarity of the component – meaning how easily can it be replace, its relative importance for the product. In this way, Intel is the top strategic supplier, who they wish to keep as close as possible, where suppliers of easily replaceable components have much lower strategic importance.

Another important factor is the business scale they wish to reach with the supplier – the transaction amount. Since Advansus is typical example of embedded company, who work with relatively smaller volume orders than consumer companies. For example introducing new supplier would create the risk of lowering the orders from the old suppliers, and in its consequence jeopardizing the relationship between supplier and customer. Lastly, they would consider factors connected with transaction costs – most visible example is the relative geography position of the supplier – ease to access etc.

4.2.3.3 Supplier Roles

Still, we can observe that relationships[7] between customer and supplier are important. There is an existing pool of suppliers, so called "Supplier List" with more than 100 suppliers onboard. This list is managed mostly by procurement, but they might create a special group (consisting for example of quality, engineering etc as well), who would help to evaluate. They would evaluate and update these regularly based on their long term policy levels, pricing, competitiveness and engineering capabilities.

They would also keep track (technology bookshelves) on the technologies their customers posses and try to develop – the component information system. This system is maintained by the engineers themselves, who would coordinate with the procurement. This is so, since they have good understanding of the suppliers and can point out where their expertise is – and highlight potential suppliers of new technologies as well.

This is very important, since it they would choose the potential suppliers for new projects from this group – based on the past experience and also their assessment of suppliers capabilities – they would choose the most suitable candidates based on the two selection criteria.

On the supplier level, Advansus is trying to promote their own products and solutions in the same way. They would send newsletters and organize events to the counterparts from their customers – to show what is the direction of Advansus` innovation and where are their medium term targets.

Mr. Chang says:

"Its something like talent management on our employees – somebody goes in and the old guys – out…but changing suppliers is costy and risky, so we try to keep them."

4.2.3.4 Reasons to invite suppliers

The main reason why they invite suppliers is their un-ability to find suitable component for their project – there is some technology distance between the existing parts and what they want. As

[7] The relationship building can be also seen on the example of the testing. Anytime they have cooperation with an new vendor, they would conduct their own testing along with the testing data provided by the supplier. After some time, once the relationship is longer and they can have better understanding if each other procedures, they would often waive the testing to save the cost. They would also often do the same thing in regard to their customer – after some time, their customer would usually agree to use the data from Advansus tests only and waive their own tests to save the costs.

Mr. Chang says – *They don't have the out of box component but they might have the knowledge. So we invite them or commit some sort of investment.*

As for Advansus` customers Mr. Chang has the feeling that the model is very similar – where their customers would also segment their suppliers into different groups based on their strategic importance. As for the main reason to be selected, however, he pointed out their technology capacity and engineering capabilities, instead of the rarity of the component. As he put it:

We have the technology and we are one of the leading companies in the industry. If you are doing something, you usually want to invite the leaders to ensure the success.

4.2.4 – Timing

If they think, that the supplier might have potential for Advansus, than they would invite them as soon as possible – usually during the concept stage already. Still, there is no real understanding on any procedure in Advansus on when to invite –and even though it considered as a generally good idea to consult earlier than later – they would still invite whenever they feel its necessary, so lare introduction of supplier into the development is also nothing uncommon.

So their own understanding of the technology plays very important role – and they would ask merely on solution of a problem, they cannot solve by themselves in any other way.

At this stage, they would mostly expect to see something they can use in their new project immediately – as he comments on this:

We expect to give us some input. Whether the existing product from the supplier or their new product to be. We won`t be expecting them to give us any concepts on our design, rather we would like to have something tangible. Some THING we can start with

.

This is the same case for the customers of Advansus as well. Advansus is usually invited in the concept stage to provide support and technical insights on component limitations and how to break these limitations in the new project.

4.2.5 Development responsibility and Development Scope

In this part the research findings regarding managerial alignment and scope of responsibilitie of each company during NPD are presented.

4.2.5.1 Managerial alignment

Mr. Chang believes, that proper alignment between the companies is very important for the development output. He mentioned, that I order to cope with the project successfully, complete support from all levels of the managerial structure are necessary. *The relationship needs to be multilayer – from entry level PM to top manager...so we go from bottom to middle – e.g. our procurement and their sales would meet every time to time to discuss new products, strategies etc and to see whether are we compatible. And as for some strategic partnerships, the top management would have also some sort of this relationship. So when the new innovation happens, it involves the involvement of every each layer.*

It is important to mention, that this structure and all the relationships build in this way would also move to the product development phase.

So once there is any issue between two engineers originating from the two companies (supplier and customer), they can easily move one layer up to resolve the issue between them – as there is already existing connection between the two managers of these engineers etc.

However, although such the relationships exist for most of the strategic suppliers, there will be negotiations and communication only when developing new strategic components. For those suppliers of commodity based components – the relationships usually does not need go that high, as the issues between these are solved on quite low organization level and rather early – and Advansus does not see the point to elevate to the higher management involvement. Moreover, since the component is not crucial for the new product, Advansus does not need to involve the supplier since their own understanding of the component technology is enough for the changes they wish to do. Involving the suppliers increases the engineering hours as well as costs and suppliers negotiation position, and they would prefer to go alone if its not very necessary.

These ties are also the way, how the management usually discuss and set the clear goals and specs of the development project – and then communicate it down on each side solely. Once the specs are set between the two sides – each party would do their own adjustments to meet the goal. Of course, the need for communication among teams on different levels might occur – and this is usually maintained by the teams themselves. Only if there is a serious conflict, the higher level would get involved and determine the quarrel. This is not that often case, but it might occur – especially in cases when they reach technology limit and need to choose another solution – for example the supplier cannot deliver the component as the specs were negotiated – and they would need to discuss with the customer on possible changes. Sometimes they can accept the changes, but if the changes would endanger the whole project, than supplier needs to adjust and provide new, different solution. It is always the customer who has the ownership and last word in discussions like this – since there is only very low overlap between the component/system knowledge between the companies and the customer usually does not provide the supplier that much information on the overall goals of the project.

4.3 Case background – Sanav/San Jose

SAN JOSE NAVIGATION, INC. is a GPS hardware and turnkey solution manufacturer specializing in mobile and marine GPS receivers/antennas. Sanav started its operations in 1990 first in the telecommunications technology. Later in 1995, in cooperation with prominent GPS companies in USA & Japan, they started the technical interflow & research on GPS technologies as well so to differentiate into other industries. Today, Sanav`s expertise is in the field of GPS-based vehicle tracking & marine navigation technologies, GPS receivers and variety of antennas, where they deliver products to their overseas customers who market those on their markets under different brand names.

Sanav, is a company that started as an OEM and then recently achieved to become an ODM and therefore we can expect they would have quite a loose relationship with their suppliers. They have the recent experience of moving up in the value chain, and they will work hard to keep their hard won position – to block out their supplier to overtake their position.

San Jose is an OEM/ODM manufacturer. As such, they cooperate with the customer, who sells the product to the market, but does not design or manufacture. These tasks are on ODMs responsibility, who needs to have a good understanding of their customer`s needs and create products that would fit in.

4.3.1Architecture

4.3.1.1 Differentiation

The GPS receivers Sanav employs in their products are rather very simple and uncomplicated products. At its easiest, they can consist of only three major components – the active antenna, the radio chip (RF/IF front end) and digital signal processor. Typical antennas for GPS include two components – the microstrip patches and quadrifilar helix. In some cases, the manufacturer might choose to upgrade the passive antenna to active one – by adding low-noise preamplifier to boost the weak signals (this might be helpful in the Sanav Defender line – which is sold in USA for home prison usage etc. but in other cases might just increase the costs and become unattractive). The RF/IF and digital processor consist of more sub-parts, but since most of these are purchased as system-in-the-box from the supplier and not individually, it won`t increase the differentiation complexity.

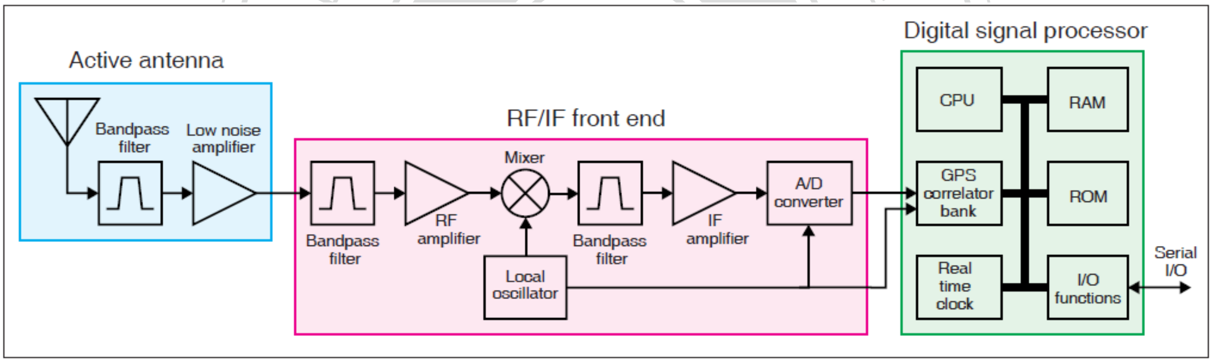


Figure 1. A GPS receiver can be constructed from just two major integrated circuits: an RF/IF front end ("radio chip") and a digital signal processor.

Source: Lanley, R., 2000

Figure 9: GPS components conceptualization

4.3.1.2 Connectivity

Also the connectivity parameter is quite low, and as we can see from the picture above, not even all the components are interconnected. Also, the process flow within the GPS receiver is quite straightforward – and we can say *sequential*: where one element`s output is the other element`s input. This is even the case of active GPS receivers – since it is not any signal reaction that would cause the products response, but it's the amplification of the low noise instead.

4.3.1.3 Product newness

In general, the innovativeness of the GPS receivers is low. The very definition of the GPS suggests, that the main reason of using such a device is to locate one`s position in the terrain. The major newness dimension in this case is the least innovative case from the matrix provided by Booz, Allen & Hamilton – the new application for existing products. As such, the GPS receivers are employed in tracking boats and shipments, fighting crime (prisoners would wear an special bracelet with GPS receiver so they can`t run away etc.), military usage and rescue – e.g. having the active GPS receivers so that help can be send faster and to an accurate position or security alarms.

The first GPS receivers were build and introduced in 1970s and the way they work now and then did not change that much. The major differences are in size and accuracy – the first GPS receiver commercially available required around 30cm of rack space only in order to operate it. Thus, the main innovation efforts were in miniaturization and increasing the accuracy, and even though there were technological breakthroughs in the process sphere, the components and their behavior within the system did not change that significantly so that we could say that product newness momentum is high – the contrary is the case actually.

4.3.2 Buyer-supplier relationship and NPD

4.3.2.1 Segmentation of suppliers and vendor management

They don’t have any specified pool of suppliers, whose they would consider for their cooperation. Instead, anytime they need any new component, the engineer who is in charge of the project would reach out and find suitable candidates to provide with such a part So for every time, they would do a business analysis of the supplier but also his component – generally based on four most important factors: price, speed, manufacture capability and quality.

The selection and evaluation is basically finding an equilibrium inside this mix - as Mr. Chen mentioned:

"We would invite many (of supplier) and then evaluate. It is not necessarily the best who will win- since we must consider cost vs. quality."

4.3.2.2 Supplier roles

These findings indicate that Sanav employs the arm-length relationship towards their suppliers and the cooperation history with the existing suppliers means very little towards the future cooperation. This finding is only reinforced by the fact, that the major decision maker on what supplier will pass is in hands of the procurement instead of the engineering – they would usually bargain with them on specs and price – so the decisions are mostly cost driven.

The volatility of the technology is also no issue when looking for new suppliers – as he mentioned that *"if there is no existing component, you cannot manufacture. So engineers, when designing new product need to consider this – that is trade off during product design. If there are no physical prototypes of the components –than we also cannot do"*.

4.3.2.3 Reasons to involve suppliers

Sometimes it happens, that there are some changes in the components necessary – but usually these are of minor importance – what is the most common issue is although they have an supplier of suitable component, the component performance is lower than they expect – and they would need them to improve this.
In this kind of situations, they would simply provide the supplier with clear targets on what they imagine and ask them to meet these. If they can`t, than Sanav will have to try to find another supplier. The cooperation and co-development is very rare.

This shows us, that the rationale of their selection process is rather straightforward – they design and manufacture based on existing components, and in this way the innovativeness of the end product is often very much affected by the development in the components suppliers offer – they usually add new functions to their existing lines.

4.3.3 Timing

Mr. Chen says, that once they learn they need the suppliers to adapt some changes on the components they try to involve them as early as possible.

From the very nature of the way they develop new products – this is later than the other two companies studied, and the information exchange is also much lower and limited.

Sanav will advice suppliers on the specs after the project concept stage and that is also when they would expect to receive some more serious prototypes to be submitted. They won`t tell them any of the system knowledge, and if – than only very little and therefore they will need to evaluate what they received. If the prototype submitted by the suppliers does not fit - it is now, after the initial testing when they expect the most changes in the component design will occur. For this they create and provide the supplier with a working document - where they specify what changes need to be done – and they expect that the supplier would meet these requirements at once. It is interesting to observe, that they would ask for an prototype from number of suppliers and then will choose the most suitable – this only posits the finding, that they do not cultivate any sort of deep relationship with their suppliers and rather source on the arms length basis.

4.3.4 Development responsibility and development scope

4.3.4.1 Top management involvement in the NPD

There is not much support from the top management from the Sanav`s side during the new product development – as they are merely preoccupied with business development and sales strategies. The top management`s role is in building good relationship with their customers and having good understanding on what are the trends they will need to adapt in the future – and than communicating this to the design. Therefore the major cooperation between Sanav and their suppliers is managed by the engineering teams themselves. As such, we can see the personal liaisons and functional exchange between the teams. The information exchange is often maintained by emails and visits of the sales engineers to Sanav to get better understanding on what is expected from them.

4.3.4.2 Degree of knowledge sharing

The development goals and the specs are usually fixed and they are not subject to any changes. Sanav does not update its suppliers on any specific architectural details – as *"the whole system is too complicated for them."* The supplies are not expected to raise any issues or ideas of how to improve the overall architectural performance. Sanav has its clear concept and since this is based on pre-existing components, and only marginal improvement in area of performance optimization and connectivity are expected. Mr. Chen describes this as follows:

"If they have changes, these might interfere with the overall system. This is not good. So this is why need to give them very clear specs on what we want. If they don`t follow – than it might not work inside our product and if we don't give them these specs, than they would argue with us."

Such an approach does not provide the supplier with much initiative.

Once the need for supplier`s improvement is identified, the frequency of the communication would be rather frequent however – in urgent cases this can be almost daily visits or con call meetings.

4.4. Case background – Thermal Management Company

Thermal Management Company (THC) is a manufacturer of PC Cases, power supply and cooling solutions. Its headquarters is situated in Taipei, Taiwan but has a number of manufacture facilities in China as well. The Taiwan company was founded in 1999, and at hte same time the company established its American HQ in California as well. They entered te Taiwan Stock Exchange via IPO in 2007.

The division studied in this paper was the cooling and fan producer. Thanks to their extensive R&D in the area as well as the clear desire to be the market leader, they were able to achieved quite a few success in this area - where in 2000 they were the first company in the world to be able to provide with comprehensive cooling for the Intel Pentium processors and in 2004 they launched the world first liquid-cooler for CPU`s.

Most of Thermal Management company`s production goes into the global technology channels. Their main customers are the end customers, who have substantial knowledge and skill so that they can build their own PC systems that will respond to their particular needs and desires. In 2009 they created a portfolio of brands, where all are differently themed (e.g. sporty, luxurious, classic etc) so that the PC enthusiasts can modify their PCs not only based from the technical aspect, but can also change the appearance and design of their computers to their liking. So, in 2010 they were able to introduce the well received and most famous product – the Level 10 Chasis co-developed with BMW Designworks – to give the user chance to create an computer like never seen before.

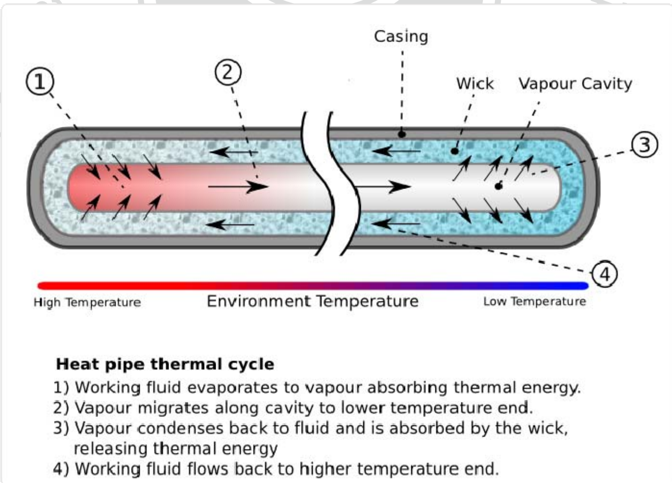
This is also one of the main aspects of their corporate culture – the DIY attitude, where they try to provide many innovative and variable products, on the highest standards.

4.4.2 Architecture

4.4.2.1 - Differentiation

The main business scope of Thermal Management Company (THC), as the name suggests is cooling devices for computers. The most common coolers they offer are the heat pipe and heat sink coolers – the two of more advanced technologies on the field of computer cooling. Coolers are rather important part of the computer – every single part inside the computer omits heat, and some of the PC most important components are designed to shut themselves off once the internal temperature reaches certain maximum in order to avoid serious damage to the components. Also, when designing the coolers, the deesingers must keep in mind the hot air outflow, cold air inflow as well as the air integration inside the PC – which requires certain level of architectural knowledge – the most important would be the size of the components as well as the degree of how much heat these components omit.

Coolers are fairly uncomplicated components, generally consisting of only 3 components – the power source, fan and the cooling device. The most of the innovation happens in the cooling device – in the materials employed as well as processes employed. As mentioned, THC employs two main technology approaches:



Source: www.en.wikipedia.org/wiki/heat_pipe

Figure 10: Heat pipe components conceptualization

heat sinks, where the sinks, usually of metal with high thermal conductivity (e.g. aluminum or copper) are placed directly on the component to be cooled. Heat from the relatively small component is being transferred on the larger sinks, causing that the equilibrium temperature of the sink and the component than the component`s temperature alone would be. Heat is than carried away by an or other similar device. Heat sinks are often glued to the components emploing special glues, thermal greases or adhesives to improve the heat transfer.

Heat pipe is a hallow tub which contains a heat transfer liquid. The liquid absorbsheat at one end and evaporate at the other end of the pipe. A heat pipe is a hollow tube containing a heat transfer liquid. The liquid absorbs heat and evaporates at one end of the pipe. The vapor travels to the other (cooler) end of the tube, where it condenses, giving up its latent heat. The liquid returns to the hot end of the tube by gravity or capillary action and repeats the cycle. This approach is much more efficient than using solid materials ever would be.

As we can see, the component and process input from the suppliers might be crucial. Still, since the number of the components (*differentiation*) as well as the *connectivity* is usually based on gluing the cooling device on the particular components – there is no extra need for any special interfaces or communication gates and the connection is basically sequential, with th heat flowing from inside the component through the cooler out – the overall product architecture may be defined as simple, low.

4.4.2.2 Time to Market

The time to market is critical issue for Thermal Management Company. There is great deal of innovation happening in the area of component innovation – in the game of increased hardware performance, often at the expense of heat management. This means Thermal Management Company must come with new, smaller and even more efficient coolers.
In addition, their business scope can be described as B2C – their customer is the PC end user. The strategy they employ is DIY – the growing group of users who upgrade their computers based on their needs instead of buying PCs ready to use from the assemblers (such as Dell or Asus). Therefore product variability and newness are a big issue here – the development times as well as time to market are short here (less than a year) and there is huge pressure on suppliers to deliver what was promised on time. This means the product newness is relatively

high, even though there are mainly improvements and revisions to existing products with occasionally appearing new product lines (in case of new cooling media).

4.4.2 Buyer-supplier relationship and NPD

4.4.2.1 Supplier segmentation

Thermal Management Company `s relation to suppliers is more rigid than SANAV`s but still not that cultivated such as of ASUS or ADVANSUS`.
All the existing suppliers, who are on the list would be managed trough the procurement. The procurement does decide who will stay on the supplier panel list and who will be removed. It is usually the procurement unit who will also search, screen and also add new suppliers to the list. It can happen, although it is quite rare, that an supplier will be recommended by the product engineer – based on their cooperation history, but also due to promising technology possessed by the supplier etc. In such a case, the engineer still has to recommend the supplier to the procurement unit who will evaluate whether to add them to the list or not.

The evaluation process is long and tough – where the procurement will check on all the costs, quality, business size, speed and also price. Another consideration is why was (in case) the supplier recommended – isn't there any extra incentive for the engineers and what will be the final control over the component sourcing and both technology as well as business risks connected?

It is only those suppliers on the list, who might be awarded with any sort of contract or consultation on new product development. No one else has the right to decide on the suppliers, regardless of the preferences than the procurement– although the engineers can go and discuss about new supliers with the procurement who might take those into consideration.

Once approved, however the supplier`s position improves significantly – especially if there is any positive track of successful cooperation. As Mr. Qin said:

"Once we have worked with them – than its completely another story. Than we have idea of what are they capable of and what can we ask for. After the first success story, we can talk about an relationship and count on them for the future."

The main factors that will decide on what suppliers to be involved are the development and delivery speed and cost – where the cost is the major decision factor out of these two. This means if there is an option to develop new component faster, but for significantly higher cost – they would choose the cheaper option. On the other side in situations when both components are about the same cost, or even with some acceptable price difference but the supplier can deliver the needed solution faster – they would choose to go with them due to the short development time and fast time to market times.

We can see, that the relationship between suppliers and Thermal Management Company is not that warm as in case of ADVANSUS or even Asus. It can be merely described as an arm-length relationship managed by procurement. In special cases, when they need to involve suppliers, they would do so primarily based on the previous experience and evaluation of the main indicators specified.

4.4.2.2 Supplier roles

Thermal Management Company does not specify any supplier roles for their suppliers. They manage them all as equals – it is not that long since Thermal Management Company was cooler component manufacturer themselves, and they still have good understanding of their supplier pool based on this experience. Therefore they don't need to create any roles on how to divide suppliers based on their technology importance.

4.4.2.3 Goal setting and planning and influence overlapping

Thermal Management Company do their own marketing and therefore would have quite good understanding of the user markets – but they must be also able to predict the trends in other components and what direction are they heading – between what trade-off will the PC component manufacturers choose –either lower heat or increased computing power?

Based on the market need, they do create product concept which will be later presented to their suppliers. They have very good idea of what they want, but they might not always be very sure about how to achieve these – especially in the case of new materials usage or how to use these materials in new or improved processes. In general they create the plans which they will present to the customer and than will discuss about what problems do they face. Mr. Qin said:

"We would listen to our suppliers on what are their creative solutions to the problem. However we always consider the price to innovation ratio. If the price is too high for that, we won`t go with that solution. The same applies for the speed."

Once they have a good idea how to solve the design problem, they will set the clear specs to everyone and make sure, that all the suppliers follow these guidelines. In case they don`t, or the solution is not good enough –Thermal Management Company will ask their suppliers to redo and provide them with solution that would work.

4.4.2.4 Reasons to invite suppliers

The main reason to invite suppliers is to optimize their products, followed by price cutting considerations. Anytime there is an supplier, who can provide with an solution that is acceptable for quality but for cheaper price – they will always go with that option, abandoning the old supplier if they can`t lower their price to the new level.

4.4.3 Timing

Suppliers are invited during the concept phase – this is when Thermal Management Company will disclose the details of their plans to them. It never happens that suppliers would be invited earlier, but it is quite common that supplier will be invited later – especially for components where they change the source (for cheaper components) or if the supplier cannot deliver the solution they asked them to do – than they will need to contact new supplier who will step in and take over the unsuccessful supplier`s task. The always try to avid this situation to happen – as that would significantly increase their risks, but it still might happen – since the supplier`s cost consideration of higher importance than technology capability.

4.4.4 Management alignment

The top management will not interfere with the development work – they will delegate this to the respective PMs and other line managers. The top management role is seen in creating the company vision and working closely with marketing on how can this be translated into the product lines.
Said this, the only top management role in any new product development would be to oversee the concept creation and then to agree on the final specifications. Once they are ok, they will

keep the controlling role over the project and merely oversee the efforts – but won`t interfere or provide any direct leadership support to the teams.

When working with the supplier, the main connection between the two companies are the line engineers, who exchange information either by email, phone calls or regular visits. Also, they do have regular weekly development meetings – where the supplier`s representative is present to point our issues and solutions to the problems they are currently working on.
There is some degree of flexibility before the final specs are agreed by the top management, but due to the fast nature of the development time, there is not much space for deeper discussions and changes during the development time itself – the ability to develop products fast is on the expense of the democratic nature of exchange – since there is no time for that whatsoever.

4.4.4.1 Degree of knowledge sharing

Thermal Management Company does not share much knowledge with their suppliers. It is only few years, since they decided to go outsource their manufacture – due to the cost consideration. Were it not for this, they would stay vertical and manufacture all the components necessary by themselves. This means they have rather excellent understanding of component knowledge and are able to employ this knowledge during the NPD process.

Also, as a consequence of outsourcing, they did move up within the value chain and they will keep their hard won architectural knowledge for themselves not exposing it to anybody. Still, they do understand that the suppliers may need such a knowledge – but they expect, that the suppliers will try to learn such a knowledge by themselves, for example by reverse engineering etc.

Therefore it is safe to conclude, that the degree of knowledge sharing is low.

4.5 Summary on cases presented

My research framework is divided into two parts – firstly comes the *Architecture as a variable* and secondly is the *Buyer-supplier relationship and NPD*. The graphical presentation of the findings is shown in this part in two tables that follow the outline of the conceptual framework of this study. Table 9 shows the *Architecture as a variable* and explains the level of architecture complexity and innovativeness on a clear comparison where Table 10 introduces the aspects of *Buyer-supplier relationship and NPD*.

Table 10: Architecture as a variable

	Asus	**Advansus**	**Sanav (San Jose)**	**Thermal Management Company**
Product Newness	High (Moore`s law etc.)	Moderate – improvements and revisions of existing products	Low – new application for existing products on best	Moderate high – mostly revisions to existing products, but have some new to world products as well
Time to market	Fast – concept to manufacture within one year	Moderate to high	Moderate	High – development time under 1 year
Differentiation	High -Hundreds of components in 15 major component groups	High – 7 areas of components groups	Low – 3 the most simple GPS have only components	Low - 3 main components
Connectivity	High - Reciprocal linkage pattern	High – Reciprocal linkage pattern	Low – Sequential linkage pattern	Low – usually glue together. No need for complicated interfaces at all

Source: this research

As we can see, in case of Asus we are dealing with very complex product architectures that have high level of differentiation and connectivity. Also, the degree of innovativeness is very high.

Advansus` products are also characterized by high level of complexity, however their innovativeness is comparably lower than of Asus.

Sanav and Thermal Management Company product are both of rather simple and non-complex constructions, the difference between these two is mainly in the level of time to market, where Thermal Management Company is very fast. They are also considerably more innovative in the area of product newness, with some new to the world products as well.

Table 11: Buyer-supplier relationship and NPD

	ASUS	ADVANSUS	SANAV (San Jose)	Thermal Management Company
1.1 Segmentation of suppliers and supplier management	Yes, strong relationship with suppliers, create technology bookshelves Main criteria for segmentation: Quality, Cost, Delivery, Technology, Service	Yes, relationship with customers, supplier pool of around 100, create technology bookshelves (components information system) Segmentation based on : -Rarity of component -Technology importance -Business scale -Transaction costs/Scale	No Segmentation Ad hoc lookup of suitable suppliers	No Segmentation, Procurement to manage the supplier pool – no interaction between any other departments. Main criteria: - Price - Development speed
1.2 **Supplier roles**	-Strategic partners with innovative component, - Strategic partners without innovative component -Commodity suppliers	Strategic to non-strategic suppliers	No roles, No relationship between supplier and customer	No roles but relationship important – based on previous experience of how fast can the supplier provide the solution

1.3 **Reasons to involve suppliers**	Technology distance between what they have and what they want to use	Technology distance between what they have and what they want to use.	Optimization – improve component performance	Optimization- develop new component fast (speed)
1.4 **Goal setting and planning (overlap of influence across companies)**	Depends on supplier position: -Most strategic (Intel) have the strength to influence whole architecture -Strategic – can influence multiple components design (apart from theirs) -Strategic suppliers have complete freedom in development means. Must only hit basic criteria set at the beginning	Specs given by customer, low influence over the architecture Supplier need to provide solution to given problem only. They can point out possible issues. Supplier has relative freedom to design solution on their own.	Goals and specs given by Sanav. No variation from specs and goals allowed/tolerated. Supplier follow blueprints.	Goals given by the customer – they hand over the plans and follow on possible discussion. Supplier can point out any issue, but this will be analyzed based on price/benefit ratio.
2. **Timing**	Strategic w. innovative component: -before concept stage for consultations -coop kick-off:	Invite to coop during concept stage. For consultations might be earlier (rare) Invite whenever	Cooperation between supplier and customer kick off after the testing (once they see limitations of the components)	Introduce supplier during the concept stage

	concept stage -Commodity & non-innovative supplier: before prototype	feel necessary		
3.1 **Managerial alignment (matrix)**	- Top management set general product specs and overall targets - Project leaders and PMs directly involved in development	- For strategic supplier involvement from top to down. - Non-strategic suppliers only mid layer max	Top management only agree on the project, but no formal leadership	Top management only to agree on the project, but no formal leadership
	-Dedicated teams (=integrating managers) - Central R&D is the hub of the project -visiting engineers	-Temporary task forces -	-Individual liaisons -Bureaucratic control	- Individual liaisons -Bureaucratic control
3.2 **Degree of knowledge sharing (architectural vs. component)**	Medium to high – gatekeeper in the form of dedicated component teams	Low to Medium (do create tech bookshelves, organize events to update everyone with the company strategy)	None	They themselves have strong component knowledge (were OEM 2-3 years ago themselves), but don't give any redundant info to supplier

Source: this research

Chapter 5 - Research Findings and discussion

This chapter is divided into three parts that have their rationale based on the conceptual model – *Architecture as a variable, Buyer-supplier relationship and NPD,* and lastly the research finding *relationship between "Architecture as a variable" and "Buyer-supplier relationship and NPD".* I decided to add this third category as there is a visible overlap between the two categories as presented in the research framework.

Every part includes a number of research findings, which are based on the cases presented. Every single research finding includes an description of the evidence from the case as well as an discussion.

The first part deals with findings connected with the architectural considerations, where the second part tackle on the issues connected with companies relationship management during the NPD. The final part is intersection of these two, it is the relationship between these two first.

5.1 Architecture as a variable

5.1.1 Product innovativeness as involvement driver

Innovativeness (product newness especially) is the main driver on when to involve suppliers. The greater the change and risks, the earlier they will invite.

Evidence from the case

The only cases when suppliers would be regularly invited to pre-concept phase of the new project development were in the ASUS case – for the consultations of design or technological of critical component that would influence the overall design possibilities.

Both ADVANSUS and Thermal Management Company usually invite suppliers during the concept stage – when they already have a good idea on what they want to bring to market but will need to consult on how the processes within different components interfere etc.

On the other side in case of innovative and revolutionary products, ADVANSUS as a supplier would often be invited very early as well – sometimes also during the pre-concept stage – and they would rarely do the same with their suppliers. This is usually the case of projects that are aimed on the medium to long term goals – as these have longer development times and more technologically grey areas with only very few or even without any technological expertise.

Thermal Management Company does invite during the concept stage or later – their products do have high innovativeness, however this is caused by extreme figures in the time to market – and therefore there is less need for any early consultations.

SANAV, the company with the lowest innovativeness usually invite their suppliers once the overall design is strictly set and they are clear on any issues with the components they want to change – and how – after the testing.

These findings indicate, that the innovativeness of the product to develop has influence over when to introduce the project to the suppliers and subsequently invite them in the NPD.

Discussion

We can see that especially in cases of ASUS and ADVANSUS, there might be quite substantial *dependence for knowledge* (Fine and Whitney) that is possessed by the suppliers – parts of the component knowledge the suppliers don't have, but need to know so they can coordinate with the other parts of the system. Their product are more complex and therefore they decide to sacrifice some of their knowledge in regard of their faster ability to integrate the components into the new product.

All three companies that were dealing with relative high to high innovativeness in their NPD mentioned, that they wanted some key insights on the component or process technology which they don`t know or possess – so they can lower the risk of setting wrong overall targets and thus development constraints and subsequent failure. The higher the risks, the earlier they would contact and present suitable suppliers with the problem.

Bozdogan et all mentioned, that ESI can increase the innovativeness of the product – in the way of proposing new possible ways and ideas to the customer. This is completely true only in case of ASUS, where they invite strategic suppliers as early as in pre-concept to discuss their design possibilities.

5.2 Buyer-supplier relationship and NPD

5.2.1 Importance of relationship

Evidence from the Case

All Advansus, Asus as well as Thermal Management Company identified, that the relationship between them and their suppliers is important. All these three companies mention, that anytime they already had a proven track of cooperation with their suppliers it is more likely that they would ask them for cooperation in the future as well.

At the same time, all of them would point out that the technology their suppliers posses is the main reason they would actually consider investments into the relationship building and it is for this reason they would build the relationship with their suppliers at the first place.

The technology the suppliers posses are the moving factor, that would determine whether or not the customer wants to have any kind of relationship with the supplier – as well as what kind of relationship. The technology is the major factor on how to rank the suppliers into different groups so that they can be selected and then invited into the new product development of an innovative project.

Both ASUS and ADVANSUS divide their suppliers based on the strategic importance of the technology their suppliers have. This is the starting point for further consideration of supplier selection – such as the innovative and development capabilities of their supplier in that particular technology necessary during the actual new product co-development.

Thermal Management Company does not have any specific supplier roles, but still they would rank their suppliers based on their competency level when considering new project.

Discussion

These finding are in line with the literature reviewed. We clearly can identify that two of the companies studied (ASUS and ADVANSUS) employ the relationship models for their suppliers instead of the arms-length. However, they don`t do so for every supplier – but only for those who are strategically vital to them and posses the technological expertise and reach. Even though we cannot identify clear role distinction as defined by Kamath and Liker, still we can see that the buyers differentiate between suppliers on a number of criteria and would estimate supplier`s specialty and fitness in every single case, rather than involving them in the New Product Development based only on the relationship. This approach more reminds Dyer`s strategic segmentation of suppliers – based on the relative importance of the output they sell.

In addition,

5.2.2 Architecture knowledge

Buyers don't share architecture knowledge with suppliers, but they do expect their suppliers to understand their architecture knowledge or at last have basic understanding of it.

Evidence from the case

There was general lack of willingness to share the architectural knowledge between customers and suppliers among all companies studied. None of the companies ever mentioned any possibility of technology spillovers, not even in the cases of very complex and interconnected products, where this might actually be of benefit to the customers.

The reason was obvious – all the companies studied felt that their true value added dwells in their architecture, which differentiates them in the value chain from merely commodity providers - and their ability to comprehend the set of different knowledge necessary to integrate all the very diverse components into one end product. In case they would need to share with the supplier – they would use different tools to make sure, that they don`t tell them more than necessary – for example provide them with architectural data necessary for the component only, or in case of more dynamic and innovative projects by introducing special gatekeepers, who would know how much can they share.

Said this, it is very interesting to observe – that all the companies studied do expect that their suppliers would try to do their own research on customer`s architectures - to educate themselves in the architectural knowledge of their customers instead having this knowledge served without any work and learning necessary. This might be also seen as a natural way how to sell their components and be more competitive on the markets. The customers believe, that this is the way the suppliers should learn about the architectures by themselves, working and enhancing their learning capabilities and only those who are the most capable of doing so are the most worthy of cooperation.

Discussion

The research confirms the findings of Takeishi, although only generally. The suppliers indeed need to understand buyer`s architectures in order to survive in the industry. The customers expect them to have a ready to go components or at least have solutions that can be employed fast and easy. Also, the customers often try to learn as much as possible about the components – the innovation happens mostly in the component hardware and the customers only merely integrate these in new ways. The ways er how to accept this information differs, but ultimately lead to the same aim. Another reason why they try to understand the component knowledge is long term control over their procurement as well as strategy. All of the four cases studied are subject to the dependency for capacity. In the case of moe innovative companies the reason is cost as well as the fact they would forego this knowledge to their ability to integrate. In the case of less complex cases, this is cost driven only. Therefore they want to have more options opened by the fact they still understand the knowledge and can have upper hand during the business relationship.

This finding also confirms the Takeishi`s presumption that suppliers should know more about architecture and vice versa. Although this is true in both cases, in the short to medium term it is much more crucial for suppliers to understand the architectural knowledge- as they need to react to the changing situation immediately. In the long term, the customers also need to understand the cultivate their component knowledge, else they risk that the constant outsourcing will destroy their leaning capabilities so they won't be able to effectively innovate any more.

There is not much long term alignment on information sharing between the companies, even though it would be helpful for both parties. Although they do understand that they should share more, nobody wants to open the communication channels as the first one (Takeishi, 1998). Also, often it is question of professional pride not to ask their counterpart for the solution, but rather do their own good engineering work and come up with the solution (ADVANSUS, Thermal Management Company). This presumption is negated in the case of Taiwan IT companies.

5.2.3 Reasons to invite suppliers

Main reason to involve suppliers is technology distance between have-want followed by optimization of components to work within architecture

Evidence from the case

ADVANUS and ASUS both identified, that the main reason why would they consider supplier involvement in NPD is the lack of some component they would like to use in a new product to be marketed. This new component to-be might be crucial for the differentiation of the end product, but since there is no such a thing they would need to invite the supplier and introduce them into their future plans of what they want to create and see whether they can cooperate.

Secondary to this, all of the companies, including Theraltake and SANAV would introduce the supplier in order to improve the functionality of components in already existing product, so that they can market next generation with improved stats to gain some competitive advantage.

Discussion

The primary reason why the Japanese companies do involve suppliers – to reduce the development times and with more innovative features was not fully confirmed in the case of Taiwanese IT companies. The findings here are somewhat supportive with what was presented by Kamth and Liker or Bozdogan et al. – the companies would be looking for the innovative capacity of their suppliers, however won`t expect that they can help them to cut down the development time that significantly. Reason why the no one of the interviewed companies mentioned the time issue as important might be the already very short development times in the IT industry, and the fact that this is simply expected. The innovativeness factor, on the other side was posited – as most of the companies studied would contact suppliers for help when trying to introduce new product features or functions.

The quality considerations – as specified by Bideault - and its improvement wasn't posited neither. All the companies studied posited on the fact, that they would examine their supplier based on the quality, however it is not always the best quality supplier wins – it rather is an compromise between many factors where quality is only one of them. One executive even explained that they would not be looking for the best quality, but rather for quality-vise satisfactory components, that would just pass their testing. It needs to be good enough, not the best of all possible.

5.3 The relationship between "Architecture as variable" and "Buyer-supplier relationship and NPD"

5.3.1 Complexity and supplier roles

Complexity has influence on the supplier roles creation as well as on relationship building.

Evidence from the case

It was only in the two companies – ASUS and ADVANSUS - both with highly complex products, where we can clearly identify a need for detailed vendor management and different vendor role creation.
It is also the case of these two companies, where clear vendor selection factors and procedures were clearly defined as well as formalized.

In the case of ASUS, all the vendors are managed by the central procurement unit, where they differentiate between suppliers based on the 5 main criteria (Quality, Cost, Delivery, Technology and Service) in two areas of components – strategic and nonstrategic. Also, they do mapping of their suppliers technologies – which is done by the R&D unit themselves – and the procurement would be working with these.
ADVASUS has the supplier list of roughly 100 suppliers, also mostly managed by procurement – but not solely as other units can provide input as well (such as quality, engineering etc.) and divide the suppliers onto different roles based on similar criteria as well as they keep track of development plans of their suppliers. The existence of the supplier list also means, that the companies on this list will be first called upon when necessary and given chance to provide with any technological solution.

SANAV and Thermal Management Company, on the other side, do not catalogue their suppliers any specific roles - they do look for new suppliers anytime they develop new product. In case of Thermal Management Company this is done solely by the procurement unit and usually the price is the main differentiator, even though the insight into technologies might be beneficial for the supplier. SANAV`s engineers look for suppliers by themselves and they would differentiate based on price and quality only – as they don`t expect their suppliers to present them with any innovative capacity (they do it themselves).

Discussion

From the above we can see the correlation between the product complexity – the number of components and the matrix of their inter-dependence – and a need to differentiate suppliers of the product components within a hierarchy to determine the relative importance of the business relationship to the buying company.

With those most important – they would try to have a more close relationship, often based on less formalized tools such as contracts or deals etc – as they can clearly identify advantages of doing so instead of managing the whole huge mass of suppliers on the arms-length basis – the suppliers are acting as the *prolonged hand of the customer* (Kamath and Liker).

On the other hand, suppliers with less complicated products tend to have no need to create any relationship with their suppliers – not even with those who posses the crucial technology necessary for their products. One of the reasons might be that the lower number of components is more easily manageable on a daily basis, and therefore they can spend more time on each component within the system, finding another solutions or even substitutes that might be much more suitable and efficient. If the system is complex enough, the company would need an partner, who can free them of way too many concerns and considerations, they might not be able to cope with. In this way, the complexity is also an driver for the creation of supplier roles with different design responsibility.

5.3.2 Component knowledge

All companies have good understanding of the component markets and supplier pool. Companies with less complex products would have deeper component knowledge, where the higher the complexity – the more they would trust their suppliers

Evidence from the case

All the companies studied will try to have good understanding of their suppliers and the markets their suppliers operate. Companies with more complex architectures (ASUS and ADVANSUS) would tend to work on catalogues of their suppliers and what processes and technologies these provide. ADVANSUS does have the vendor list, which is updated by new supplier technologies on regular basis by both engineers and procurement, where ASUS does have the special groups, who will specialize on screening markets for particular components. This later approach is also similar with Thermal Management Company and SANAV, where single engineers would be given the responsibility to reach out and search for suitable suppliers before a new NPD begins.

Another trend is the level of component understanding – where the companies that have to deal with high complexity architectures would forego some of their component knowledge, so they can concentrate on the overall coordination and integration of the whole system. ASUS completely trust their suppliers will come with the solution they want – based just on very rough specs provided by ASUS and give them the complete freedom in how will they reach the goal. In ADVANSUS case, the suppliers have relative freedom to come up with an solution – where as long as the PM believes it will fit the architecture and operate in the way he wants than it is good enough.

SANAV and Thermal Management Company, on the other side had an excellent understanding of the components they were about to purchase. Thermal Management Company often even advice the suppliers on what exact changes they should do so they can enjoy the improved overall design so that the overall functionality increases, where SANAV gives clear and detailed specs of what they want and will not tolerate any deviation – as this does influence their planning effort.

5.3.2 Discussion

The reasons for this to occur might be twofold – once the complexity is lower, the buying company is not preoccupied with the integration process and might have greater opportunity to understand the components they employ. Also there is the fact, that the business model of these buyers is based on optimization of existing products rather than more radical innovation. The second one is more prosaic- they both had the very recent history of moving up the ledder from OEM to ODM. Their buy or make decision is more than less affected by the cost issue – it is cheaper for them to purchase the component from third party than do it by themselves, but they still keep the knowledge so they can use it in the future if necessary. Their main dependency of these companies is the *dependence of capacity* (Fine and Whitney, 1996) – as their “make or buy” decision when employing suppliers is based mainly on the cost considerations. Thermal Management Company can do the components themselves and only few years ago they did produce these – but chose outsource so they can save cost strike to move up a bit within the value chain for higher profits. SANAV does not want to invest into the newest machinery as they don’t believe this will bring them any competitive advantage, as they

often change components and their suppliers.
In the ADVANSUS and especially ASUS case, there is a strong *dependence on knowledge* – the companies already forsaken their component knowledge and need suppliers for their insights in technology – if they try to develop the product without this knowledge, the time frame spend on the research might be much longer.

5.3.3 Managerial alignment

Managerial alignment does follow the architecture of the product to be developed. Speed to market is constant, innovativeness variable.

Evidence from the case

It is the central R&D unit who is in charge of new product development projects together with procurement unit, who supports for business negotiation and closing business deals with customers. The central R&D is in charge of the whole product development, but they do create independent "specialty teams" that do have greater understanding of particular components. These teams than work as an gatekeeper – they filter information to the central R&D and also translate necessary information to the suppliers. The communication strategy depends on the importance of the customer`s component as well as on situation and timing. Usually they do consult over the phone or do meetings, but sometimes they would create an task force in charge of specific problem or even employ visiting engineers (both supplier o customer and customer to supplier) who will work with the counterpart on longer terms for more complicated projects, where they will invite all the involved parties to take part on the discussion.
Advansus` alignment is more straightforward, with the multilayer management control. They follow the importance of the component, where for supplier of more important components or cases with higher complexity they also want to work with supplier`s higher level managers and engineers for extra support. In such a cases they would sometimes consider to set up an temporary task forces, that would be effective until not resolved. On low level complexity or innovativeness this expensive approach is not necessary and they would only go wit personal liaisons or bureaucratic control mechanisms.

Since Advansus and Thermal Management Company have only few interfaces between themselves and their suppliers, there is not much need for elevating the matters higher than to individual liaisons, as the amount of data to be transferred is not that huge and can be easily managed in even small teams.

In addition we can see, that for projects with very fast development cycles (Thermal Management Company, Asus), there will be an general tendency not to make the discussions longer than necessary. This is the case of all four companies studied – since the development time in IT are short in general and none of the customers is welcoming delay of any sort.Asus would discuss with suppliers only on the most important things and than let them to figure out the rest – and as long as it suits they are happy with that. Sanav in cases when speed is critical would not accept any changes and ask suppliers to redo their design if it does not fit – and same case is for Advansus.

5.3.3 Discussion

We can see, that the main mediator for the managerial alignment in Taiwan is the architecture considerations, instead of the innovativeness as proposed by Olson et al (1995). The time to market is an issue already and all the companies tried to be as efficient and quick as possible – so if there is not any requirement from the product newness, the alignment will always be as described by Olson – with only very few discussions, clear deadlines and district division of labor. If we were talking about complex product with new parts, however – the management alignment will become loser and more open to new insights from suppliers, with special ad hoc teams formed where they can discuss all the issues involved from different angles so that the customer can get better idea on what are the options – they can simulate different possibilities and choose the most suitable. Of course, this approach is much more demanding on resources and therefore not cooperation with every single innovative component provider can be done in this way. It is only those more strategic important suppliers of whole subsystems, who would be considered worthy of such an cooperation.

Chapter 6 - Conclusion and suggestion

6.1 Conclusion

The main question I asked myself before I started working on this research was – what are the ways suppliers can defend themselves against being replaced when the architectural innovation occurs? What should they do so they can participate on the next generation NPD, learn the new technology and skills so they won`t be left behind?

This area is quite unexplored area, and my decision was to start with the component buyers, from where it might be more visible to see what kind of recommendations give to the suppliers on how to behave so they can stay o the cutting edge of innovation.

For doing so, I answer the 3 main research questions:

Research question 1:

Do all the companies manage their suppliers in the same way? Are all the suppliers same important?

Based on the cases studied we can see clear differences in the way the different companies presented manage their suppliers.

- Companies that face higher product complexity tend to categorize their suppliers into hierarchical roles based on specific criteria. Suppliers of these companies are not given same importance, some of them even have strategic importance and would have the position of an almost equal to the buying company where on the other hand, suppliers with commodity based product are easily substituted and seen as unimportant.
  In addition, buyers with more complex products would often tend to create a relationship with their suppliers. The main selection criteria are technology, innovative capacity, price and quality.
- Companies that face lower product complexity manage their suppliers on the arm length relationship. The main selection criteria for them is the price and quality.

Research question 2:

What are the main factors to employ the suppliers into the new product development? Under what circumstances are buyers more likely to work with the suppliers on the new product development?

- The main factor is the technology distance – between what buyers have and what they want to employ. Often they want an off the shelf component or detailed plans for one rather than advice – they don't have the time to wait for the component to be fully developed. Secondary reason is the optimization of components
- Suppliers who have some sort of relationship – based on previous successful cooperation experience are more likely to be asked for cooperation in the future.
- Suppliers who have excellent component knowledge as well as understand the architectural knowledge of buyer`s system is in advantage on which they might be awarded with the business.

Research question 3:
What are the main problems when managing suppliers in the new product development? Are there any risks involved when suppliers work in the new product development?

- The main issue identified in all cases was the equilibrium management of negotiating power as an direct impact of the scope of business exchange with the supplier. The customers were mainly concerned of the tradeoff between having one strong, sole provider with the technology capacity (who will have strong influence over their design) or more weak suppliers who are not interested in investments into the relationship due to weak returns.
- All buying companies are concerned about the communication, especially during the new product development. They need to talk to their suppliers fast, with the right people and preferably face to face. Geography proximity of suppliers to customers is important.
- Disputes between the development teams on a solution of particular problem may cause increased cost, longer development time or even failure. Even in cases they set clear specifications and have business deal, all suppliers will also set the project ownership so the owning part (always customer) has the last word over the solution – the suppliers can point out problem, but must accept the solution.

6.2 Suggestion to the industrial practitioners

The problems companies are facing are both long term and short term. Different kind of action and tactical preparation is necessary in both cases, therefore the following part is divided into two subparts – the long term action (this action is to be implemented continuously) and short term action to be done once when the immediate threat of architectural knowledge is identified.

6.2.1 Suggestions to suppliers of long term character

In the long term run, the suppliers of buyers who are dealing with **more innovative and complex products** should try to promote their existing technologies as well as their plans for the future and where they wish to innovate next to their buyers – to get their plans on the radar of buyers to be present in the technology bookshelves of buyers.
The informal exchange and regular updating of their long term technology goals between buyers and suppliers and technology consultations should be supplier`s highest priority.
There are many platforms the buyers use and the suppliers can employ – be it special seminars on particular technology problems organized by the buyers, or in some cases through media (Digitimes etc) and even newsletters or word of mouth in between the engineers might be of benefit.
Also, it is a good idea to set a regular meeting between the top management of both companies, where the top management has the chance to meet up and do an update on the highest level as well. This will help to clearly show what are the strategic gals of both organizations so if there is any need for strategic alignment, the managers will have a good chance to raise these issues and see whether there is any chance of cooperation. Also, increased activity of sales engineers on the lower level towards the procurement is always an good an suitable entry strategy. In this way, they will be able to create a relationship on all levels, and be there the case of any new project – the suppliers can prepare in advance for the bidding or selection.

For suppliers who deal with buyers for **less complex products**, the main considerations should be the cost, quality and delivery issues together with an understanding of what exact incremental changes to their design are important, so that they can help the customers to increase the overall system efficiency. They should not rely on the relationship that much, but rather try to learn more about their customers needs and how can use the existing relationships to communicate how can they target these needs. Being initiative is important – the customers can no possibly know what is their every suppliers specialty and therefore it is the suppliers role to up-sell themselves a bit. But in general, such a suppliers does enjoy the major benefit of the modular design for supplier – the relative ease of switching suppliers and as long as there is no incentive for them to innovate, than just continue selling the modules to whoever buys them.

Although the modularity literature shows, that suppliers does not need to concentrate on the architectural knowledge and should deepen their expertise in the component knowledge – for the long term standpoint an basic understanding of the supplier`s architectures and where are they heading seems to be crucial for the supplier`s survival. It was shown, that the buying organizations do have rather good understanding of component knowledge and will spend time to learn it. Moreover, the customers do expect their suppliers to do same and reward these suppliers with more business as they are better positioned to cooperate with them. It is therefore crucial for the suppliers to have an overall good idea of what are the architectural challenges their customers dealing with and how can they help with solutions from their component perspective. This means there might be some simple, incremental innovations of the components, which might bring new functions to the end product etc. – which the suppliers might target through study of their suppliers markets.
Plans or concepts for these are good, but the buyers will always be asking for an ready to go off shelf component first – they won`t need to wait for it and even better- there is less risk that the development of such an component will be failure –so they can start the system testing for it right away.
Of course, there might be substantial tooling investments in the case of an very new design – but when dealing with an architectural innovation, the main issue is usually In the interfaces and connectivity of the components rather than some substantial core changes to it – which can be prepared in advance and is something the suppliers should be ready for and should be studying.

6.2.2 Suggestions to suppliers for short term action

As shown above the supplier`s understanding of the architecture will have direct impact on their immediate actions when contacted by the buyers – supplier should try to have a number of off-the shelf solutions to target the requirement. It is very possible, that in the case of architectural innovation the change to an existing component will be very small but being immediately ready for such a requirement might be the reason why the customer would choose that particular supplier. The point is that the supplier must be able to recognize the threat of architectural innovation in the industry and be ready for that.

Also, in case of more complex cooperation, the supplier should be ready to accept some level of control of the buying company over their development team. All the companies researched mentioned that they like to have the last word over the technical development as an exchange for having the chance to work on the next generation technology to the market. This will have dual impact on the supplier – firstly this should be taken into consideration when negotiating the business deal where they specify the business terms of the cooperation. Considering that the supplier is waiving some of the control over their resources and also ownership to another party, there should be some substantial benefit for that. Suppliers should be looking at specific pricing strategies, procurement numbers as well as the grace period for which they cannot market the new technology or products they just learned through the cooperation. The second impact is the technology they are about to learn through the cooperation – they should choose only such a projects, where they believe the customer has the power to set an industry standard or that such a new innovation might be so important to other possible buyers, so that accepting such an cut off of their own managerial control over the company future should be favorable.

Also, the suppliers should take the advantage and participate on so many co-development projects as possible – even if the business scope of such a cooperation were just marginal. The cooperation is the only way how to train and cultivate their employees to be ready for any future cooperation opportunity. It is also way how to establish the buyer-supplier relationship. The more the supplier is open to cooperation with the customers, the more readily they can be seen as a good potential partner for future projects, where the suppliers insight might be crucial for buyers success.

6.3 Research Limitations

At the end of my paper I must humbly acknowledge a number of research limitations to my paper. Although I was able to answer my major questions I set at the beginning of the research, we can clearly see that this research could go another step further and explain more.

First, I studied only four companies, and although I tried to have as variable sample to cover the wide range in the field, this surely is a shortcoming. Therefore it is quite difficult to generalize the results for larger groups – in the future I would recommend to use larger samples to avoid this shortcoming.

Second, the results come from on single industry and therefore cannot be interpreted in general, and at this point I need to the question on how should we interpret the findings: is it the industry specifics that stands behind variance between the results, or can this be interpreted as more unbiased result?

Third, most of the issues covered in this study come as a result of my extensive preparation work with literature and secondary materials, however none came from my direct experience with the topic. My primary research questions and also the research direction was preliminary skewed by this and therefore my study will need critical review from business practitioners, be it managers or engineers.
I believe many important areas of NPD troubling today`s managers still stay uncovered as a result of the fact, that they were never researched in the secondary literature. Greater fusion or cooperation between scholars and practitioners in the field of NPD literature is needed.

6.4 Suggestion to the future research

6.4.1 Suggest use other research methods

In my research I used case studies only. This approach gives more analytic and complex explanations on the issues and questions faced. On the other side, due to the fact that most of my data was obtained through direct interviews with representatives from the companies, these data might be biased in multiple ways. The interviewee might be reluctant to answer truthful (accurate) answers rather than more acceptable ones due to the fact of face to face contact. Also there might be some bias due to the conversation misunderstandings as well as this method is very time consuming and therefore allows small samples only. For the future research, I would recommend to use questionnaires or customer variable as well. This might decrease the sample size, since less time is necessary and questionnaires might be distributed to large number of subject. Also they might bring more standardized way to data collection and evaluation.

6.4.2 Suggest employ supplier`s perspective

In my study, I researched the relationships between suppliers and buyers from the customer perspective. This will give us quite good explanation on why are the suppliers involved into the NPD and also bring some insights on strategies how can they be selected. Although this is valid approach, I believe that in the future research the suppliers should be subjected to research as well. Once having the points of views of the both sides analyzed, we can present with an more complete and comprehensive research as well as answers.

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