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Future Product Ecosystems : discovering the value of connections

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Abstract: Product Ecosystem Theory is an emerging approach to help understand the value networks that exist between products within a system. As products become increasingly interconnected, understanding the value that is gained from those connections becomes ever more important. This paper explores the concept of product ecosystems and how this concept can be employed in mapping current products' evolution as well as that of new product conceptual development. Case studies using both hindsight from historical design and foresight from new product propositions reveal the different connections that take place or need to be considered in the emerging landscape of product ecosystems. This paper seeks to contribute to Product Ecosystem Theory through a discussion of the literature and analysis of emerging connections within a product ecosystem revealed in selected examples, as well as by proposing a conceptual tool to help map out products' value networks.

Keywords: Industrial Design, Product Ecosystem Theory, Innovation Theory, Internet of Things.

1. Introduction

Products can meet with success or failure for many reasons. Whilst the authors acknowledge that success can take many forms, in this context we are considering success to be commercial success. That is; one that makes a satisfactory financial return on investment. According to the substitution effect in consumer choice theory, demand is considered to be proportional to perceived value and demand in essential for commercial success (Sanchez-Fernandez & Iniesta-Bonillo, 2007).Therefore, in this context, perceived value and success are proportional. Conversely, failures are associated with a lack of perceived value; that is a failure in the premise of a product, or failure to communicate the value to customers.

Because approximately 70 – 80% of all new products fail in their first year of launch (Savoia, 2014), understanding the value that products provide becomes very important. The traditional approach of Value Analysis or Value Engineering (DeSarbo, Jedidi, & Sinha, 2001; SAVE International Value Standard, 2015) is useful as it allows a value to be ascribed to each function of the product. This is effective for stand-alone products where all the value of the product is intrinsic to that product. However as products become more reliant on extrinsic ecosystems (Williams & Chamorro-koc, 2013a), a more holistic approach is required. This paper aims to contribute to our understanding of how products within an ecosystem gain value from that ecosystem.

Product innovation has long been a mechanism for product differentiation and a means to gain competitive advantage. It is widely accepted that innovation can be either disruptive or incremental (Christensen, 1997; Verganti, 2009). One of the main characteristics of disruptive innovation is high risk and potentially high gain whereas incremental innovation is associated with lower risk and correspondingly lower gain. Disruptive innovation creates new value networks, it disrupts existing ones; therefore understanding these value networks is seen as a key strategy for managing the risk associated with the introduction of new products.

Product Ecosystem Theory is an emerging approach that helps visualize and understand products' value networks by identifying where value is created and transferred between the various parts of the ecosystem (Williams & Chamorro-koc, 2013a). As previously mentioned, value and success are proportional and so increasing the overall perceived value of a product may be possible by identifying links that provide value and perhaps questioning the links that don't provide value.

Whilst Product Ecosystem Theory is still developing, a gap in extant theory is perceived as there are no widely accepted strategies or methods in place for mapping and understanding the flow of products' value in complex interconnected ecosystems. As there is a general trend towards products that exist in more complex ecosystems, Industrial design must naturally follow this trend. For example a television of the 1960s required a power supply, transmission of programs and not much else. A modern television in contrast, may sit within an ecosystem of DVD players, pay TV, streamed content, free to air content, remote controls, surround sound systems, internet connectivity and so on. Additionally, as the "Internet of Things" (IoT) gathers momentum and wireless communication between products becomes commonplace, products will interconnect in many new ways. Increasingly designers are now required to consider and/or design the entire system. As products become increasingly interconnected and interdependent, the requirement to understand products' emerging ecosystems becomes more important. Currently there is a lack of suitable methods to enable this. To this end, and complimenting current Product Ecosystem Theory, an initial model has been devised to identify existing and emerging connections within product ecosystems. .

This paper discusses a part of a larger research project that investigates how Ultra Small Vehicles (USVs) interact with and gain value from their ecosystem and what aspects of the ecosystem can be modified in order to improve the perceived value of USVs (Williams & Chamorro-koc, 2013a). The main aim of this aspect of the ongoing research is to identify what aspects of the ecosystem can be modified in order to improve the perceived value of the USV and make them more desirable. The need to devise a method evaluate this type of value flow and connections, led to the consideration that products tend to behave in ways that are analogous to natural ecosystems. The study of natural ecosystems is a mature science, and thus, many methods for mapping and describing natural ecosystems are already in place and can be adapted for use in the study of product ecosystems. For example, in nature the notion that the introduction of a new species into ecosystem can have a dramatic impact, often leading to the extinction of other species that are unable to compete is an idea that dates back to Charles Darwin (Oldroyd, 1986). In a product's ecosystem, the introduction of a new product often has a similar impact on the incumbent products, also leading to their demise (Massey, 1999). This is especially true of disruptive innovation.

This paper introduces a discussion about the theory of Product Ecosystems and the critical importance of understanding products' value within an ecosystem. The intrinsic relationship between products, innovation and ecosystems is then explored. On this basis, a theoretical framework for product evolution is presented, and an Industrial Design approach is presented through two type of case studies, one responding to hindsight and exemplified with existing product innovations, and the second responding to foresight approach with examples from industrial design students' IoT design projects. A model for the analysis of product evolution and ecosystems interconnections is presented and discussed. Finally, the conclusion section lays out the steps for the continuation of this research and development of this emerging tool.

2. Products, innovation and ecosystems

Products are becoming increasingly complex and increasingly connected. Many products that were stand-alone are now reliant on other products as well as the environment in which they exist. This means that many products are platforms that now have little or no inherent value, but rely on gaining value from the ecosystem of which they are a part. For example, an iPad gains much of its value from its ability to connect with other devices, including the internet. The ability to add functionality in the form of apps is also a key value provider. Even the charger is also part of the ecosystem, without which the iPad would become inoperative. Many of these interactions provide obvious value where others may not be as obvious. As perceived value is clearly an important component of product success, understanding that value is critical. The importance of this is illustrated by the statistics of new product failures. Whilst the definition of a product failure is open to discussion, it is frequently cited that between 70 – 80% of all new products are commercial failures (Savoia, 2014)Of course there are many reasons why products fail, many of them unrelated to the premise of the product however as previously noted, disruptive innovation carries a higher risk of failure (Christensen, 1997). The consequences of failure can be ruinous for a manufacturer both financially and in terms of brand reputation. So even small improvements in success prediction have the potential to save money, effort and brand reputation.

The term “Product Ecosystem” is most often used to talk about products that are connected electronically. For example the “Apple ecosystem” is a term used to describe a suite of products such as an iPhone, a computer, an Apple watch and an iPad. These products communicate with each other and therefore create an ecosystem where each product gains value from the other products. However, ecosystems are more complex than just the products mentioned. For example the software needs to be considered because without it the whole system has no value. Value is also gained through content on the internet, so this is also part of the ecosystem. Without an electricity source the entire system becomes useless and so on. The value of an individual component is less and sometime in fact worthless when removed from the ecosystem. Therefore the value of the system becomes greater than the sum of the standalone parts.

Our research suggests that once the product ecosystem is understood it then it is possible to manipulate the ecosystem to favour one product over another (Williams & Chamorro-koc, 2013a). For example to address the problems of traffic congestion and pollution, vehicles that reduce these problems should be encouraged. Ultra-Small Vehicles (USV) are a class of vehicle specifically designed to address these problems. However in the context of the current road-vehicle ecosystem, the perceived value of USVs is less than that of conventional cars (Mitchell, Borroni-Bird, & Burns, 2010). For example the drivers of USVs are still affected by the traffic jams created by larger conventional cars. It has been suggested that creating special narrow vehicle lanes and thereby manipulating the product ecosystem, the perceived value of USVs can be increased (Williams, 2014).

Departing from these considerations, the following section presents a theoretical framework of product evolution, which provides the basis for the development of the initial model for the analysis of product ecosystems.

3. A Theoretical framework: Product Evolution

When one looks at sustaining innovation it is normally clear to see how a new model is related to the previous model and how there is a clear progression from one model to the next. With disruptive innovation the predecessors' influence is not always as obvious as with sustaining innovation; however it is always there and often comes from more than one source. For example the DVD player has clearly adopted technology from the CD player as well as the VCR. Whilst the CD player still exists, (though arguably in decline), the VCR is no longer made in any reasonable quantities and has nearly ceased to exist.

From this it can be seen that all new products have clear predecessors and therefore can be seen to have evolved from other products (Crawford & Tellis, 1981). Some product lines evolve rapidly while others evolve slowly over time. Some products are regularly superseded by others in a gradual progression whilst occasionally new products emerge that are radically different to those that currently exist. Occasionally a product line will decline and eventually disappear altogether, becoming extinct. All products compete for market share while only the fittest thrive. These patterns of behaviour are seen in both nature and consumer products (Massey, 1999)

Broadly speaking, both biological species and consumer products respond to external opportunities and threats. In biology the opportunities and threats come from the environment and other species and for products the opportunities and threats come from the market, social trends and legislation (Williams & Chamorro-koc, 2013a). They all tend to thrive when they are well adapted to exploit opportunities and decline when unable to adapt to threats. They both compete for resources; whether those resources are consumer dollars or food.

In biology, the principle of phyletic gradualism describes the process where the rise of a descendant species slowly displaces an ancestral species a clearly traceable lineage. This is based on small changes in physiology that allow species to become better adapted to their environment so they can thrive. In a resource constrained environment this tends to displace those ancestral species that are now less able to exploit those resources. This has parallels in the evolution of products as new products with slight changes are released onto the market. If the changes are well received by the consumer then the product will be successful; if not then the changes will be dropped in subsequent models. This is partly described by the term "sustaining innovation" coined by Clayton Christensen (Christensen, 1997). The difficulty with the concept of sustaining (or incremental) innovation is that it presumes that each new model is a slight improvement on the past and therefore likely to be successful. The reality is that 80% of all new products fail within the first year of launch (Savoia, 2014). When one looks at value network of products that undergo incremental innovation, the values tend to be similar to the previous generation with relatively small performance improvements. As a product line matures it becomes increasingly difficult to continually improve performance and therefore increase perceived value.

By comparison, disruptive innovation typically has a completely new set of values. Some of the existing performance characteristics may in fact be less that previous products and there will be some completely new values. If the sum of these values is perceived to be superior to the predecessor then the new product is likely to be a success. Product Ecosystem Theory helps identify and document these value networks, which can assist Industrial Designers to develop products that are able to capitalize on extrinsic value from the ecosystem.

4. A Design Research approach

Product Ecosystem Theory has greatest potential when applied to the conceptual premise of a new product as opposed to a specific product design. Product Ecosystem Theory allows us to explore both historical and conceptual/future product ecosystems, so that products can be developed that are able to fully exploit the latent value within the ecosystem. With a lack of appropriate ecosystem theory and tools, Industrial Design has typically tended to focus on developing stand-alone products with little consideration of the ecosystem. As previously mentioned the overall value of a product is comprised of both intrinsic and extrinsic values that contribute to the perceived value of a product. To create maximum perceived value for a product, designers need to consider the value obtained from the ecosystem. This can be achieved by considering past and future ecosystems: that is through gaining insights from hindsight as well as foresight thinking. Hindsight thinking refers to the understanding of past and current ecosystems. The past can be analysed to give rich insight into factors that contribute to the evolution of products. The study of current ecosystems allows for identification of strengths, weaknesses, opportunities and threats. In foresight thinking, evaluating potential future ecosystems has greatest potential to identify future product ecosystems, and new product connections, which in turn, would provide a framework for devising new scenarios of emerging landscapes of new product ecosystems.

4.1 Hindsight thinking: Past ecosystem analysis

Successive iterations of consumer products exhibit similar evolutionary patterns as those found in biological ecosystems (Tobias, 2007; Williams & Chamorro-koc, 2013b; Zhou, Xu, & Jiao, 2010). Evolutionary theories such as phyletic gradualism and punctuated equilibrium can be observed not just in biological evolution but are analogous in product evolution. (Massey, 1999). Phyletic gradualism describes the gradual evolutionary morphology changes in species over time. In contrast, punctuated equilibrium describes long periods of stasis occasionally punctuated by rapid changes or branches in species (Gould & Eldredge, 1993). This can be seen in Figure 1

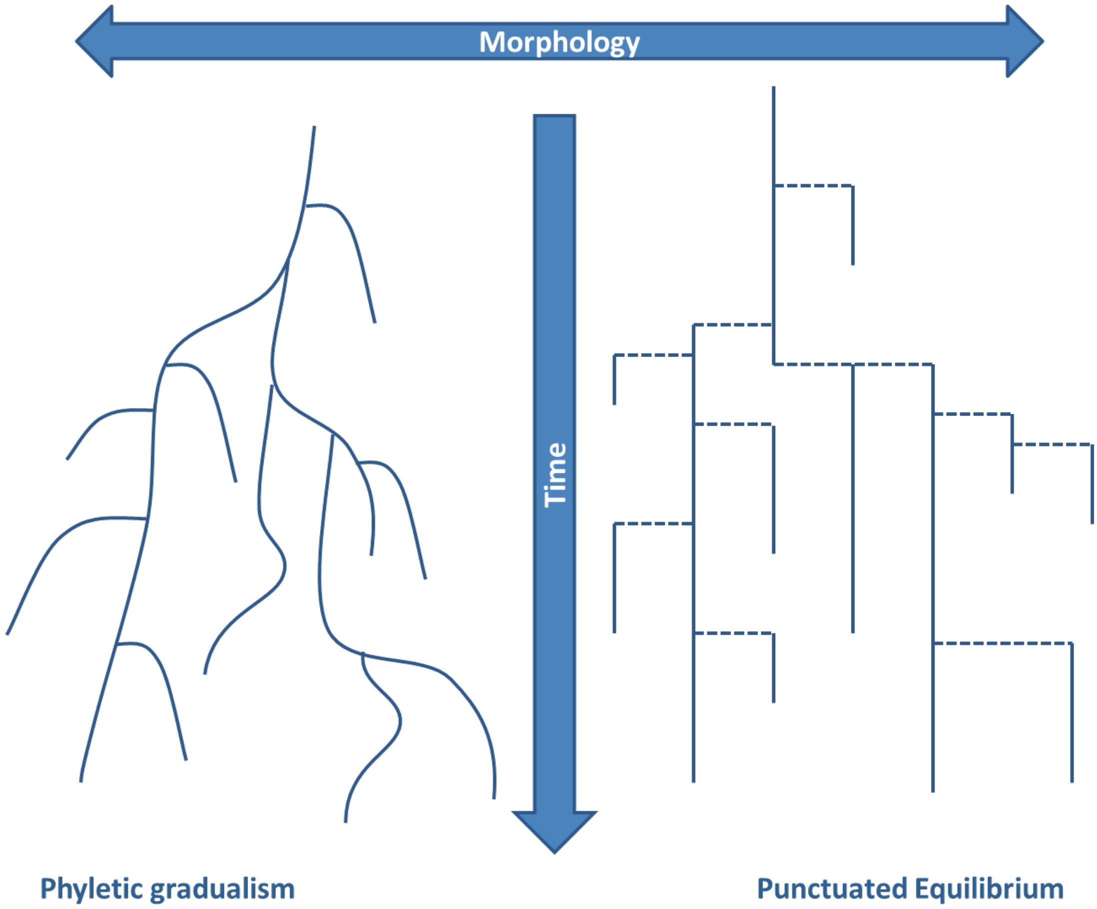

Figure 1: Graphical comparison of phyletic gradualism and punctuated equilibrium. Reproduced from (Williams, 2014)**, based on (Gould & Eldredge, 1993)**

In biology, changes in morphology are driven by environmental pressures or opportunities. When the morphology of a species changes and is better suited to the environment, that species tends to flourish (Oldroyd, 1986). Sometimes gradual changes are not enough to keep up with a changing environment and radical change is required. The same patterns can be observed in product lines. As we know that in products, radical change is achieved through disruptive innovation and gradual change achieved through incremental innovation, we can see direct analogies between disruptive innovation and punctuated equilibria as well as incremental innovation and phyletic gradualism. As in nature, the two forms of evolution occur alongside each other in product evolution. Figure 2 depicts an example based on the evolution of watches, where incremental innovation is depicted by the horizontal green lines and disruptive innovation is depicted by the vertical red lines.

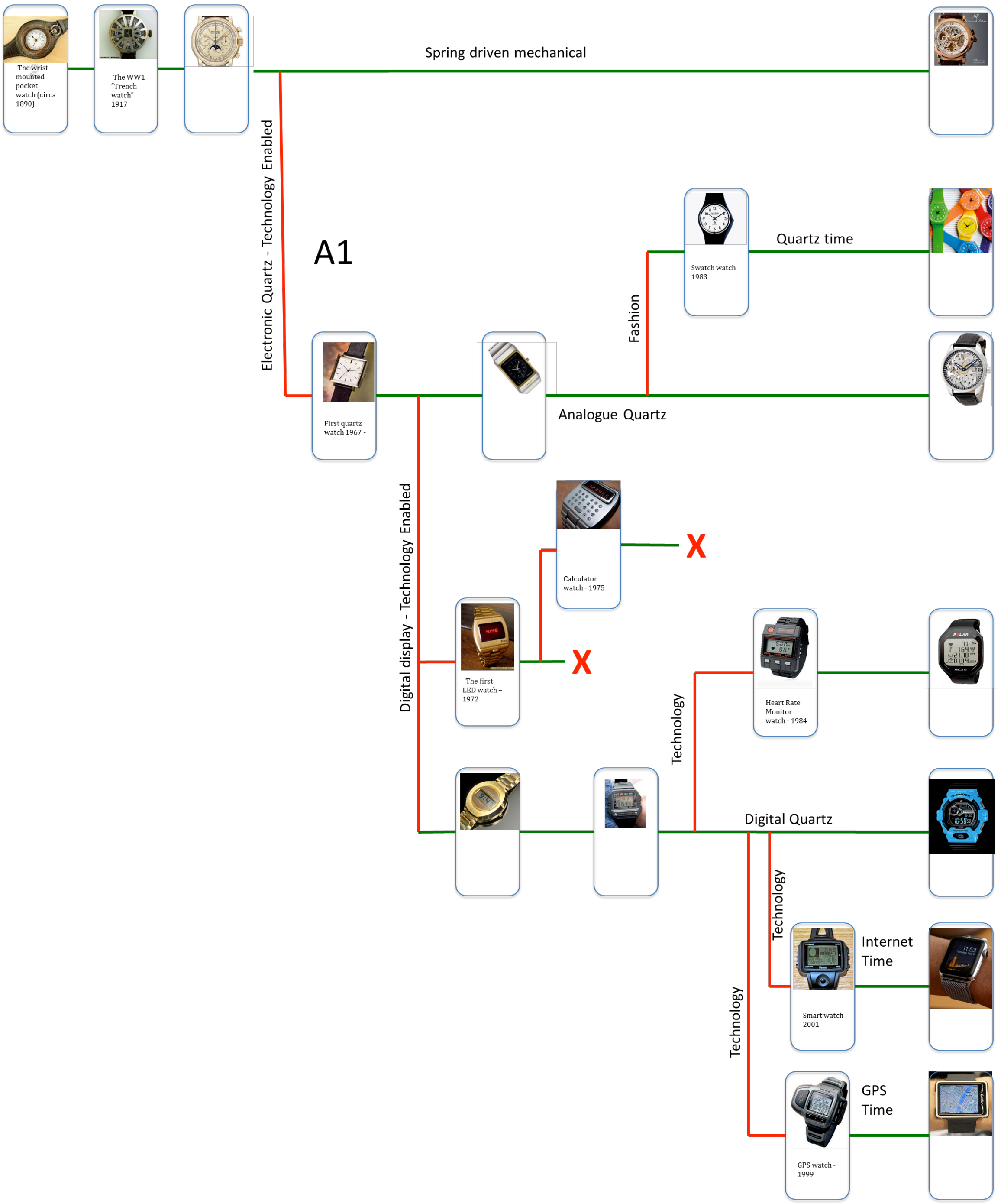

Figure 2 - An evolutionary diagram of watches. (Williams, 2015)

Each step in the evolutionary diagram can be evaluated to see what new technical opportunities allowed the change to take place and what additional values the product offered that contributed to its success (Williams, 2015). This type of evolutionary diagram allows the analysis of the products that failed and became "extinct" giving insight into the reasons behind the failure. There are many well established methods for this type of analysis such as Value Analysis (Rich & Holweg, 2000), FMEA (Carlson, 2014), and SWOT analysis (Pardeshi, Shirke, & Jagtap, 2010).

4.2 Foresight thinking: from Present Ecosystems to future ones

Current ecosystem analysis can be used to visualise the value and influence of each component within the ecosystem. Figure 3 shows a partial ecosystem map for the automobile. The map shows the complexity of components that provide value to the automobile. The main reason for producing a current ecosystem map is that it allows a convenient baseline for proposing future scenarios. For example we might pose the question about what will need to be mapped in the ecosystem of electric cars. We may conclude that service stations and mechanics will offer less value for electric cars than they do for conventional cars and therefore may need to rethink their business models. By understanding the interdependencies of the car ecosystem and modifying the environment accordingly we gain control over the design of the viability of the car.

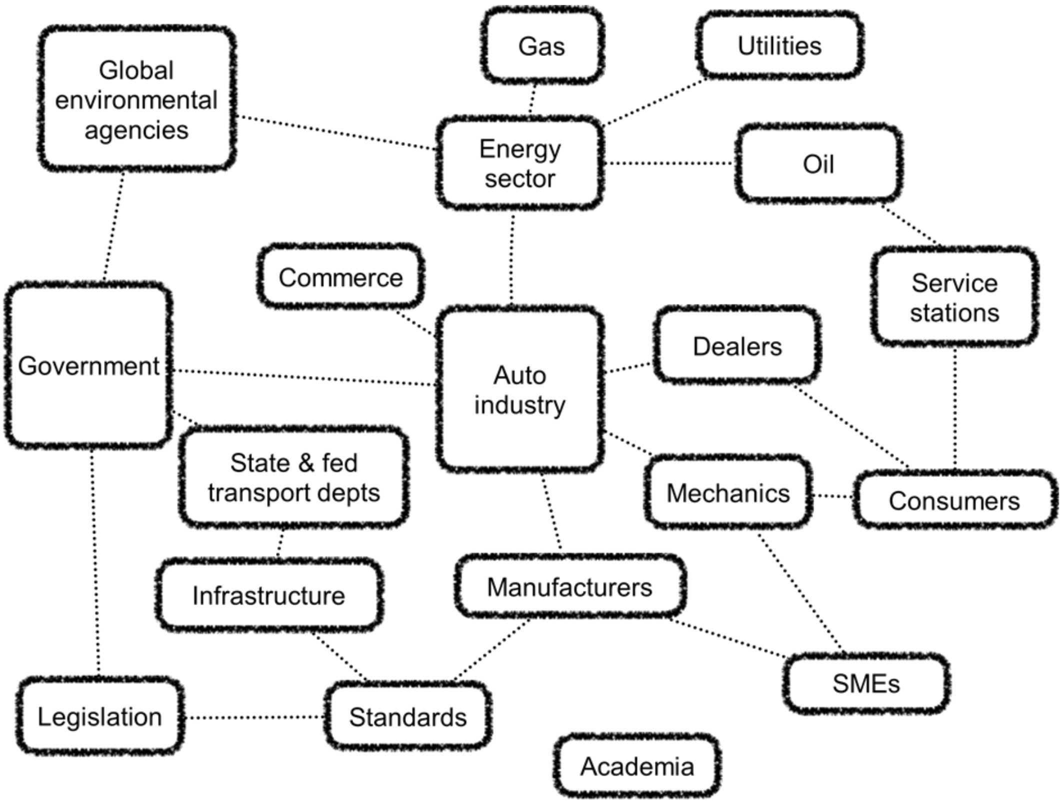

Figure 3 - The current automotive product ecosystem (reproduced from Williams & Chamorro-koc, 2013a)

In Figure 4 we can see a simplified product ecosystem diagram for a DVD player. The solid lines represent critical value transfer and the dashed lines represent components that add value but are not critical. The arrows show the direction of value flow. That is, the arrow points to the receiver of value. For example the TV is a critically important to the DVD player.

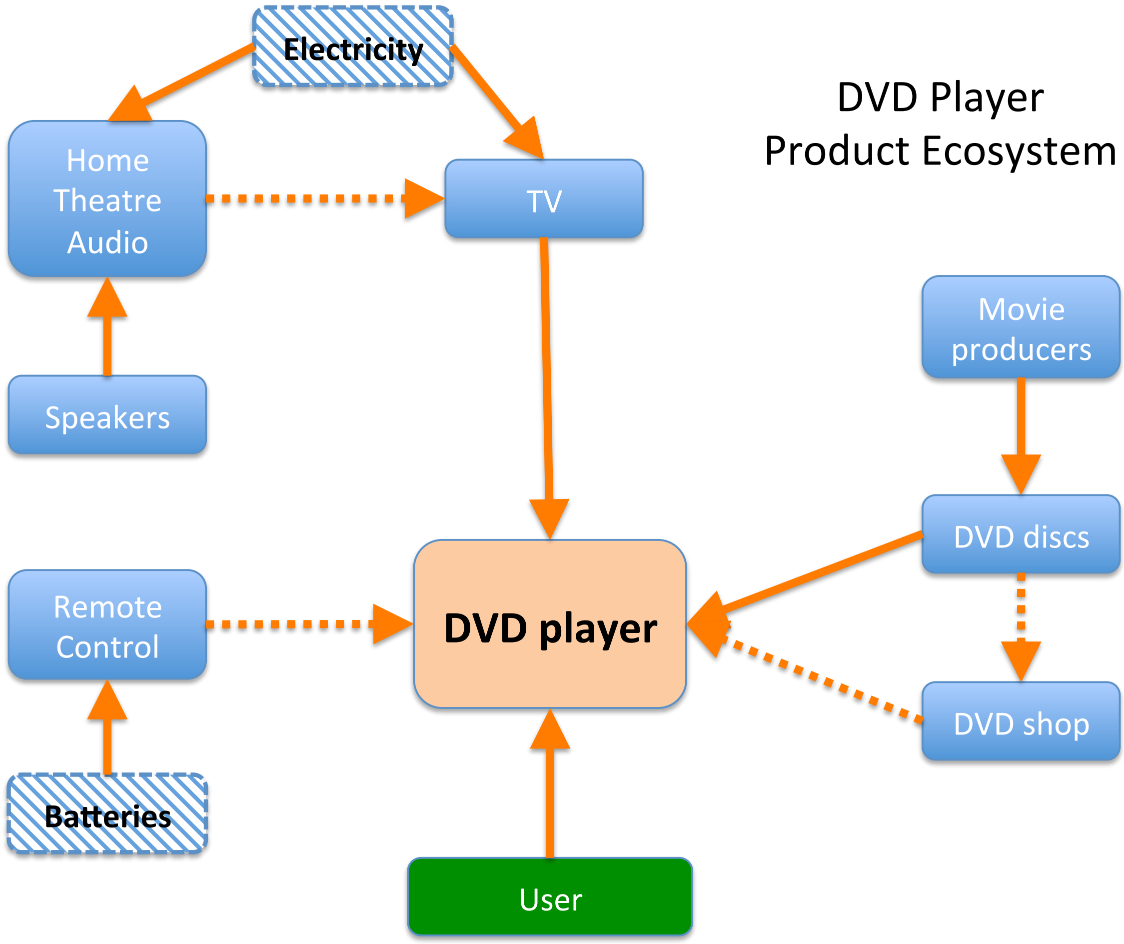

Figure 4 - The product ecosystem for the DVD player

In Figure 5 we can see the product ecosystem for direct movie streaming overlaid on the DVD product ecosystem. This demonstrates the components that are removed from the system. This is only a partial map. For example it could be expanded to include a modem, internet service providers (ISPs) etc. The quality of the internet connection is an important factor in value flow.

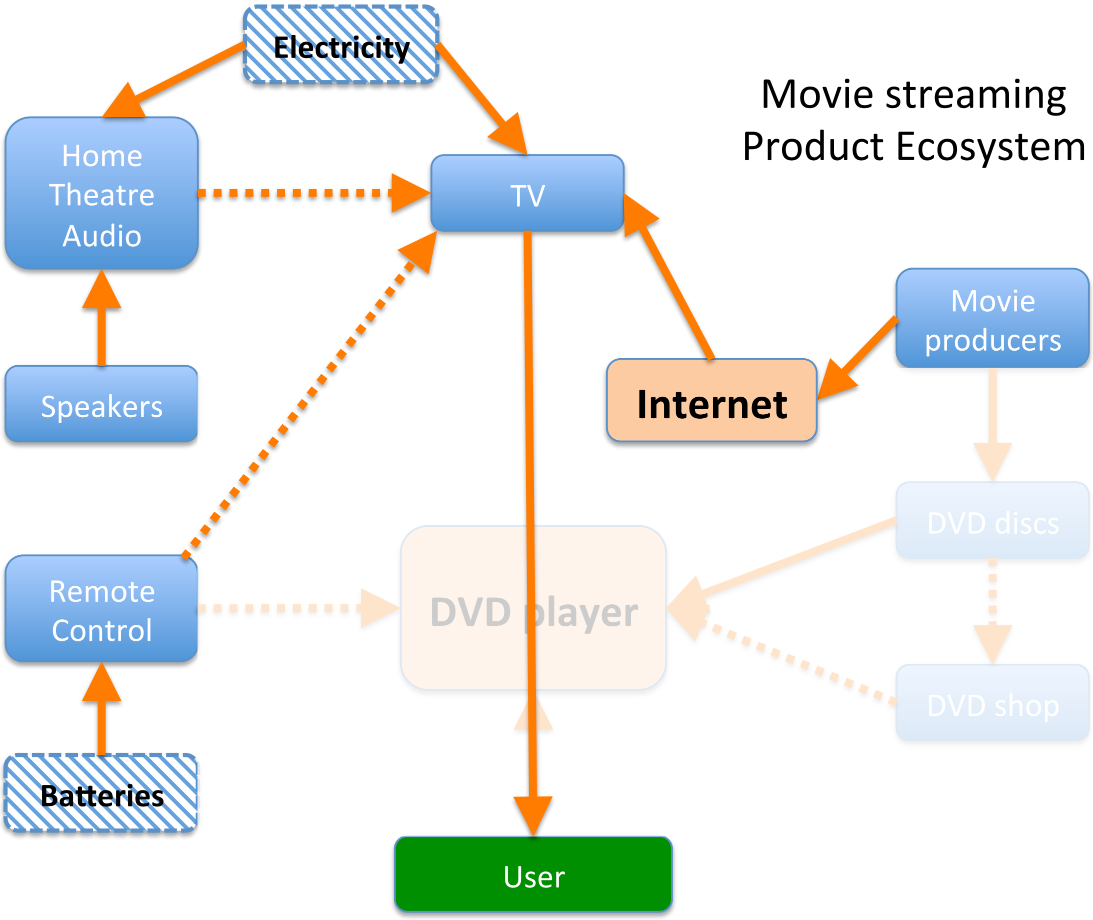

Figure 5 – The product Ecosystem map for direct Movie streaming

Therefore by understanding the potential value generated as the consumer environment changes and opportunities that technology allows we can start to predict which products are likely to succeed. More importantly it allows us to see what environmental variables can be modified to make a product more or less viable.

The diagram presented in Figure 3 provided the foundation for an initial 'tool' or conceptual proposition to test the concept of foresight thinking and identification of value flows and connections in emerging product ecosystems. The diagram was presented to the third year Industrial Design students at Queensland University of Technology who were working on the design of an interactive product for the near future (five to ten years in time), within the IoT concept, and for the future generation of the older adult. It was explained to them that they could employ the tool to identify and outline the connections that their new product designs would require in order to exist and benefit the end user and society. Product ecosystems from three students' design projects are presented here: the domestic hobby products, the scuba diving experiential devices, and the bed-ritual products family. Product ecosystems and connections were produced by the students according to their project needs. These are discussed next.

In the case of domestic hobby based products, the students selected home-based activities that older adult enjoy doing on their own, but like to share with others. These are: mowing the lawn (a predominant DIY weekend activity in Australia), bird watching, and watching a rugby match. As a large portion of older adults in Australia prefer to maintain their independence and live on their own, students designed products to support these activities and enrich the users' experience by augmenting their socialisation potential through interactive functions. Figure 6 shows the students' product ecosystem map where the connections of the three interactive products to people, the central hub, and services are depicted. In this case, this product ecosystem map demonstrate connections that aim to add value to existing services and products in the household through a digital infrastructure supporting each of the new product designs.

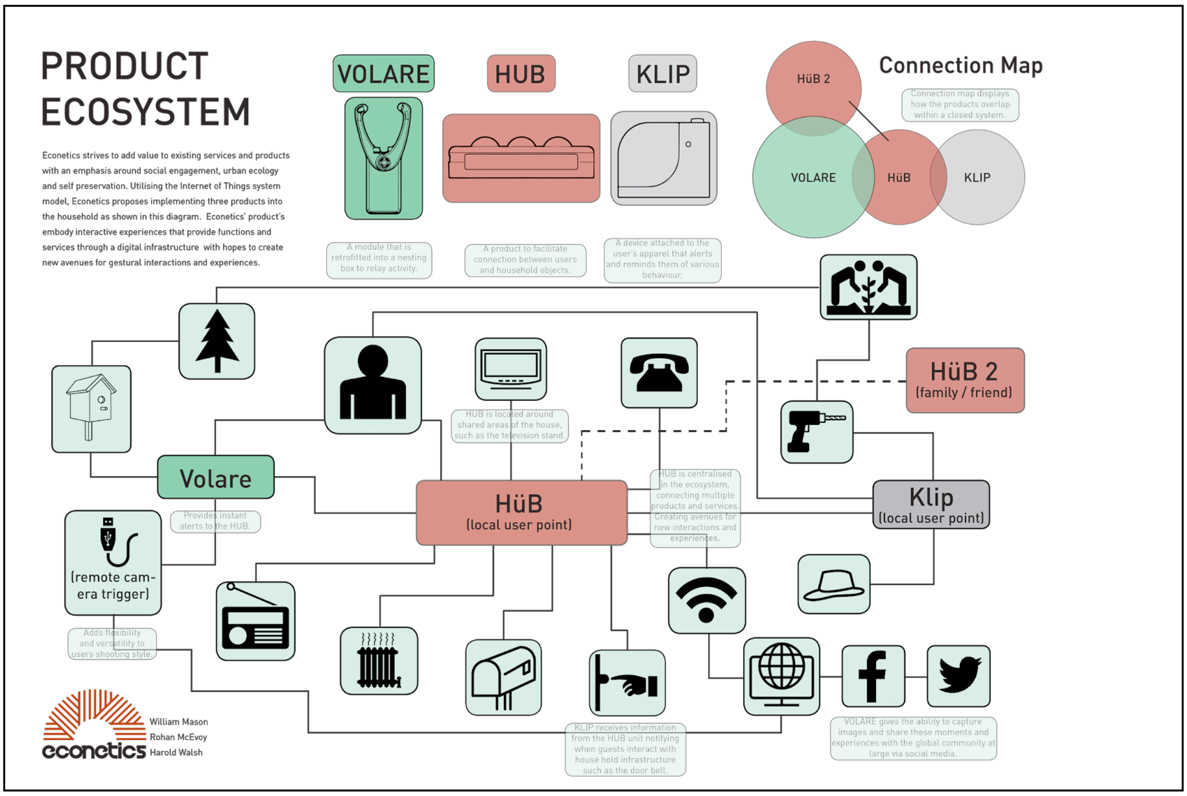

Figure 6 - Students design project – domestic hobby products

In the case of the scuba diving experiential devices, the students explored the topic of active older adults who have enjoyed doing scuba diving since very young and who are not ready to give up this activity due to age. However, as physical and cognitive decline affects older adults performance and ability to continue being active, students focused on designing products that assist older adults' performance and experience when diving. Figure 7 shows a product ecosystem map of the three different products that are part of the scuba diving gear. The diagram shows the connections of each product to the scuba diving activity, connections between the products, and connections to a social network.

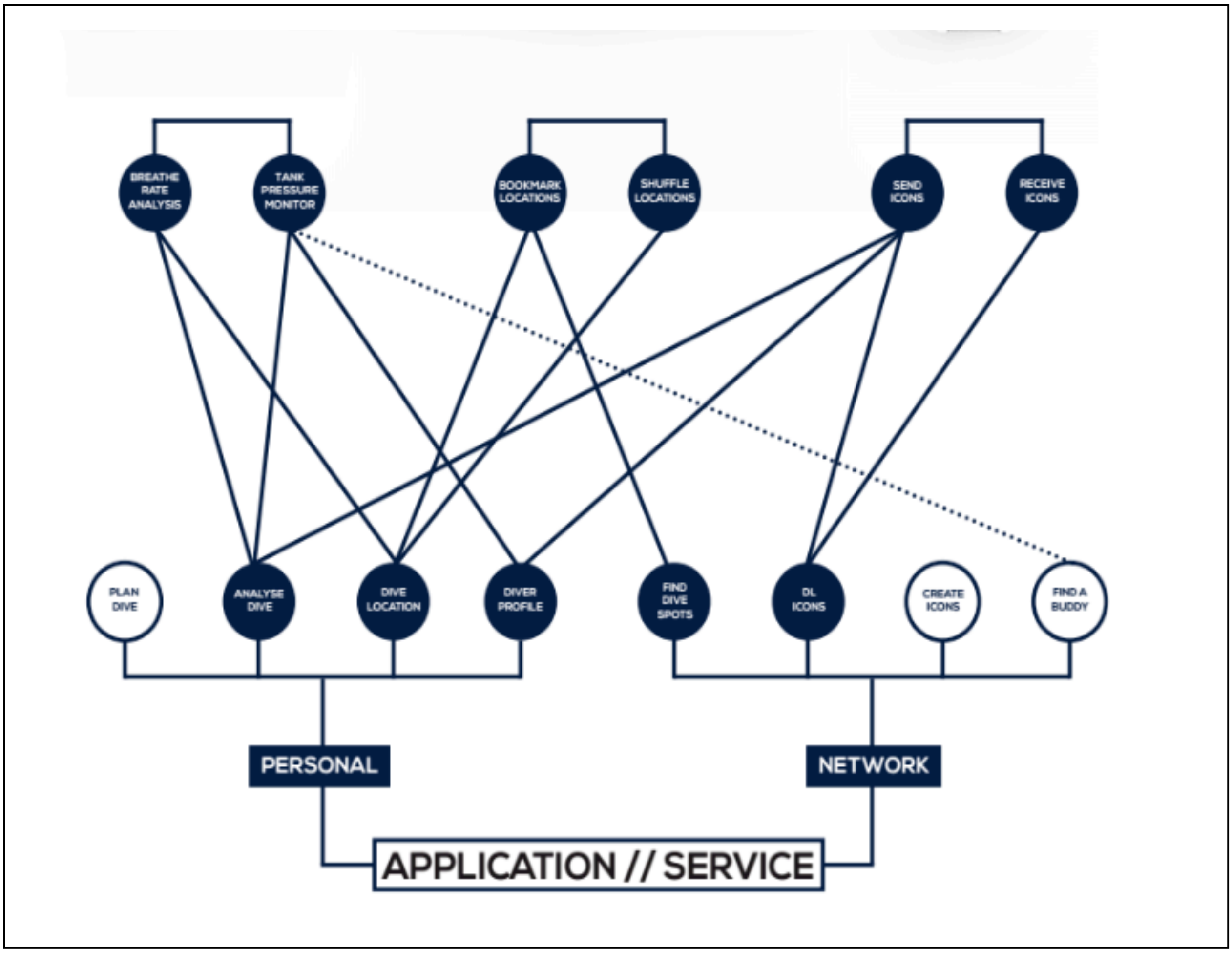

Figure 7 Students design project – scuba diving experiential project

The third student project example is the bed-ritual products family. This project proposes an enhanced way of preparing to sleep and waking up. Many older adults include a relaxation activity as part of their preparation to sleep; reading a book is one of them. Another part of a bed-ritual activity is the wake up, which commonly is assisted by a noisy alarm clock. To enhance and augment these basic bed-ritual activities, the students worked on two product designs that would be seamlessly integrated into the persons' ritual activities, helping to time and provide a relaxing reading time before sleeping, and prompting a gentle wake up experience without the startle caused by the mundane alarm clock. Figure shows the students product ecosystem map that clearly depicts two parallel branches that connect to a diversity of services, support network, and other products.

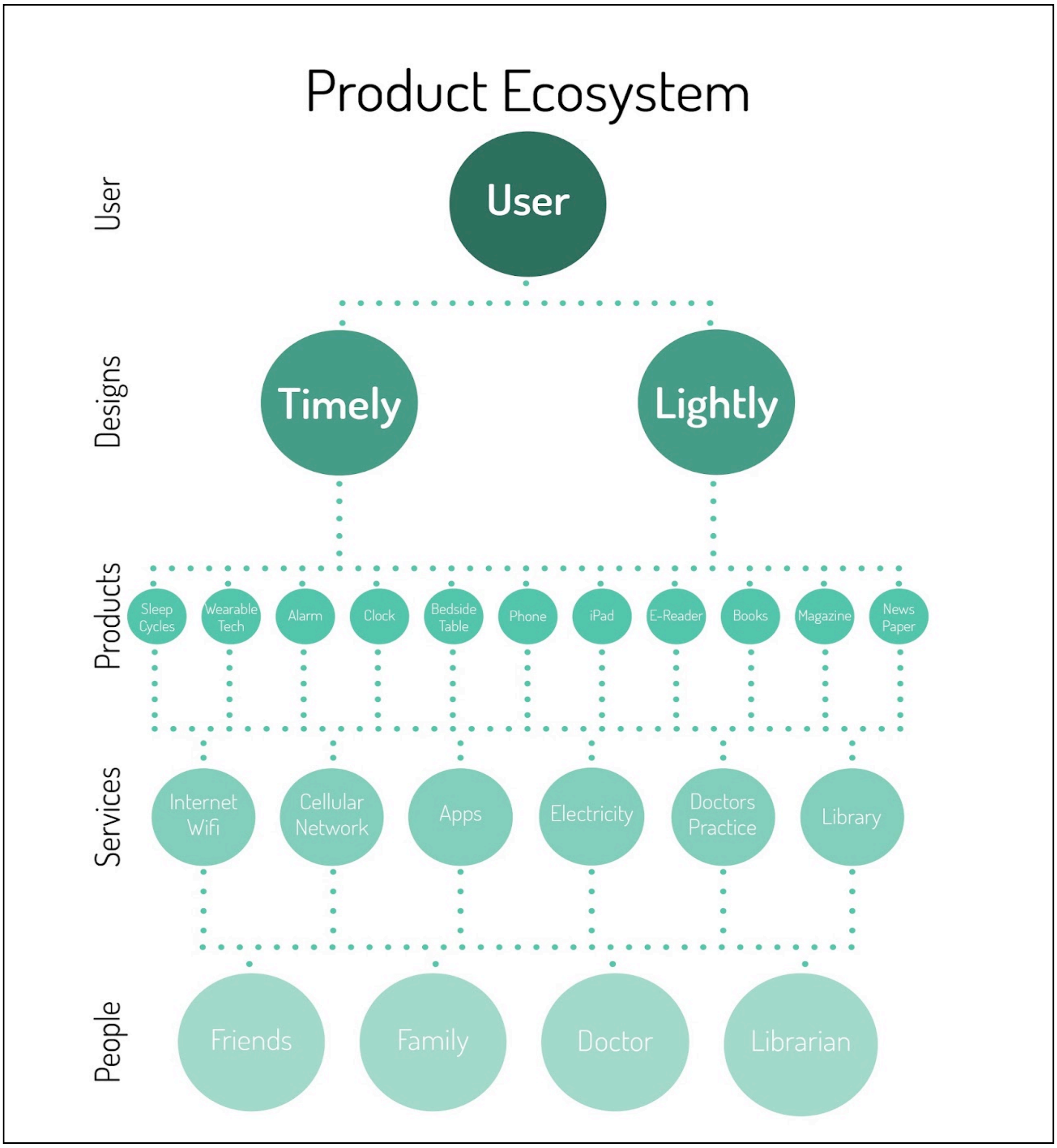

Figure 8 - Students design project – the morning ritual products family

In this exercise the students were only asked to show the links within the ecosystem without complicating the exercise by qualifying the actual flow of value. The aim was to see how students approached the mapping process and to see what commonalities emerged.

From this we observed three distinct product ecosystem maps that demonstrate three types of connections: (a) product to product, (b) product to system, (c) product family. Each of these connections would potentially lead to different value flow as they respond to different types of products' innovation.

5. Discussion

This paper proposes two tools. The first is a tool to chart the evolution of a product and the second maps out the ecosystem of the product. Neither of these tools generate outputs of their own. Rather they both are techniques for creating a visual scaffold that allows evaluation using existing methods of analysis. It is this analysis that that generates empirical data that can be used as guidance for the design process. For example, once a product ecosystem map has been created for a product it can be used to rank the other entities based on the amount of value that they provide the product. This can be useful in deciding which entities to optimise the product for. As is often the case with design, judgement is required to determine what level of analysis is required.

The two visual scaffolds created can also be described as maps of the value network. The evolutionary diagram represents the longitudinal value network and the ecosystem map represents the current or proposed value network. Whilst analysis of each of the nodes identifies the values gained from other entities in the ecosystem or how value is added over time, in practice it seems that this level of empirical data is not always required. It seems the process of creating these maps allows a designer to visualise the context in which a new product might lie. This is similar to other techniques used in product design such as Persona creation. It is not necessary to analyse the persona empirically to be of use, rather it is the process of creating a Persona and the ability to visualise that person's archetype using the product that makes the technique useful.

The nascent techniques of creating evolutionary diagram and ecosystem mapping need further evaluation to determine the usefulness in the design process. Initially this evaluation will take place with students, as the turnover of projects is typically more rapid when compared to professional projects. Refinement will be an important part of this process. Once an effective and reliable tool has been developed, this should be evaluated with professional projects.

6. Conclusion

The need for tools to help design and configure ecosystems is becoming more apparent as products become increasingly interconnected. The "Internet of Things" promises a level of functionality for many products that was impossible until recently. Simultaneously the way that we interact with products is changing significantly as well. This suggests that Industrial Designers will find a decrease in emphasis from traditional areas of aesthetics, form and ergonomics to that of interaction and ecosystems. This follows a progression in the way that we interact with products. When Industrial Design was a new discipline, product interaction was typically with levers and handles. With the increase in electronic products, interaction involved knobs and switches. We are now moving into an era where interaction is through gestures and touch, increasingly remote from the product. Whilst ergonomics and form have been the subject of design research for many years, interaction and ecosystems are relatively new subjects and therefore adequate tools are lacking. This will require an approach to product design that is a significant departure from the traditional approach and this research aims to help fill the gap in knowledge.

As previously mentioned, this paper is part of a wider research program investigating product ecosystems. It is still a work in progress that has been initially tested with industrial design student's design projects and further research is required in order to provide a fully resolved tool (or tools) for use in design practice.

Future research in this area is to investigate mapping ecosystems to identify either a suitable way to plot out all types of ecosystems or to identify different categories of ecosystems and develop mapping methods for each. Our initial research with design students suggests that there are different types of ecosystems that will require different approaches although it might be possible to develop a unified approach. The next area is to qualify and perhaps even quantify the flow of value within ecosystems. As product ecosystems are often very complex this would appear to be a very time consuming task. However it may be that only certain types of value links need to be evaluated. Further research in this area is required.

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Human factors and product usability

Interface design of design tools

Design process