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Using intellectual property strategy to assess and develop product architecture

Stephen Smith

Using Intellectual Property Strategy to Assess and Develop Product Architecture

By
Stephen E. Smith

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the Department of Industrial and Systems Engineering in the Kate Gleason College of Engineering of the Rochester Institute of Technology.

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CERTIFICATE OF APPROVAL

MASTER OF SCIENCE DEGREE THESIS

The M.S. Degree Thesis of Stephen E. Smith has been examined and approved by the thesis committee as satisfactory for the thesis requirement for the Master of Science degree.

____

Paul H. Stiebitz *Advisor*
Associate Professor of Industrial Engineering
Associate Professor of Microsystems Engineering

____

Dr. James B Taylor, Ph.D.

____

Mr. Alan Steves, MBA, BS ISE

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Chapter 1. Introduction

Overview

Intellectual property (IP) plays an important role in value creation strategies of the new economy. IP is now used as leverage, a bartering tool and a source of income in itself. New ideas and innovations can bring about huge shifts in existing industries and the formation of new ones. Many times these shifts are directly related to how a new idea or innovation is presented to the consumer in the form of product architecture and how that idea or innovation is protected in the form of intellectual property.

Product architecture can be thought of as an embodiment of intellectual property. How a corporation decides to present their research and development findings to consumers through architecture can be the difference between a successful product and a waste of money.

Given the pressures on product development teams to create revenue for their organizations, how do they decide what marketplaces to enter, what products to produce, and how best to protect their designs through architecture?

Problem Statement

The goal of this thesis is to create and demonstrate a tool that relates product architecture with corporate intellectual property strategy. The process created will focus on two types of organizations, those that develop breakthrough technologies and those that follow into existing markets. Research questions will be addressed for each type of firm.

Market Leaders:

1. How do leader firms integrate new technologies into well-protected and hard to duplicate products?

Market Followers:

2. Given that a market is worth entering, how do follower firms develop the best-suited product for entry?

To answer the above questions, research into the realms of product and systems architecture as well as intellectual property will be conducted. This research will yield existing ideas that are prevalent in each field. These ideas will be manipulated and synthesized into a single decision tool used to address each research question.

Upon completion of the decision tool, real life examples will be addressed and discussed to highlight the potential of the tool. The examples will be presented in the form of case studies. The first of which will describe a follower firm attempting to penetrate an existing market. The second case study will examine a leader firm incorporating a breakthrough technology into a new product architecture.

Thesis Outline

The following chapter in this thesis will provide a summary of the literature review. Topics such as system and product architecture and intellectual property as it relates to product development will be covered. Ideas and concepts from highly regarded authors in each field will be presented and explained.

The third chapter will present a further discussion of product architecture as it relates to product development. Specific terms, definitions, and concepts will be explained.

The fourth chapter of this thesis will provide an overview of the decision tool developed in response to the research questions. This chapter will describe how ideas discussed in the literature review and product development chapters were manipulated and synthesized into a new decision process.

In the fifth chapter, the first case study will be presented. This study will relate the decision tool to the example of a follower firm attempting to penetrate the ink jet printing cartridge market. The study will also show

how the decision tool can be used to successfully create a legal product similar to something currently existing.

The sixth chapter will describe the second case study. This case study will show how a leader firm could use the decision tool to integrate a new technology into a well-protected commercial product.

The seventh and final chapter will provide a summary of work included in this document as well as areas for further research. It will provide a synopsis of how ideas developed in the second and third chapters were used to create the process detailed in the fourth chapter and how that process was implemented in the fifth and sixth chapters.

Chapter 2. Literature Review

The literature review for this thesis centers on two main topics. The first area is systems architecture, specifically when applied to product development. The second is intellectual property as it applies to both business strategy and value creation. Each of these topics alone is a valuable tool for market share protection and growth, but combined and focused strategically they can become a powerful weapon against competitors.

System Architecture

Defined

Maier and Rechtin present architecture as a response to complexity (7). They cite examples of the first applied system architectures developed 4,000 years ago by the Egyptians. The pyramids presented a large and complex construction problem. For the first time individuals began to realize that there were benefits to studying not only the individual tasks, but also the relationships between them based on order, function, and interface. This understanding allowed the Egyptians to do something that many still believe to have been impossible.

A product can be thought of in both functional and physical terms (Ulrich and Eppinger 131). The functional aspect relates solely to *what the product does*. The physical nature of the product involves the actual components of the device. Two similarly functioning systems can look entirely different and share no common parts. In a similar fashion, two products that share common parts may use them in different ways to provide different functions.

Lynch and Sage further expand on the idea of systems architecture, "It is the integration of subsystems and components that give systems their superiority over a set of elements that do not work together without integration (177)." Given this definition, we can begin to think of systems architecting as a value-added process at the very beginning of a product life cycle. Through architecture, we can give a product or system a strategic advantage over competitors.

Maier and Rechtin emphasize the stakeholder's role during the architecting phase. "Systems architecting strives for fit, balance, and compromise among the tensions of client needs and resources, technology, and multiple stakeholder interests" (21).

A stakeholder may be thought of as anyone who would come into contact with the system (Boehner quoted by Stiebitz, 2002). In some cases the terms 'customer' and 'stakeholder' may be used interchangeably. "From a customer point of view, a system is everything that is required to meet the need of the customer to achieve some particular purpose" (Lynch, Sage 179). This responsibility of the system to each customer or stakeholder presents another level of complexity associated with the overall task of developing an architecture.

Product Development

Architecture plays a major role in product development. It can be thought of in both a 'coarse-grained' and 'fine-grained' perspective (Stiebitz 2002). Coarse-grained architecture provides an overall plan for product families and platforms. It describes what technologies will be used, what functionality the products will provide, and will be used as generally a strategic idea. Fine-grained architecture deals with the specifics of a design. This type of architecture would entail choices related to a single product. Fine-grained architecture is related to the form, function, and behavior of an individual product.

Coarse-grained architecture should mesh with a corporation's strategic business goals developed by senior management. Coarse-grained architecture choices serve to determine where an organization is in a given technology life cycle. Technology life cycles tend to resemble 'S' curves (Figure 2.1) which relate time and value.

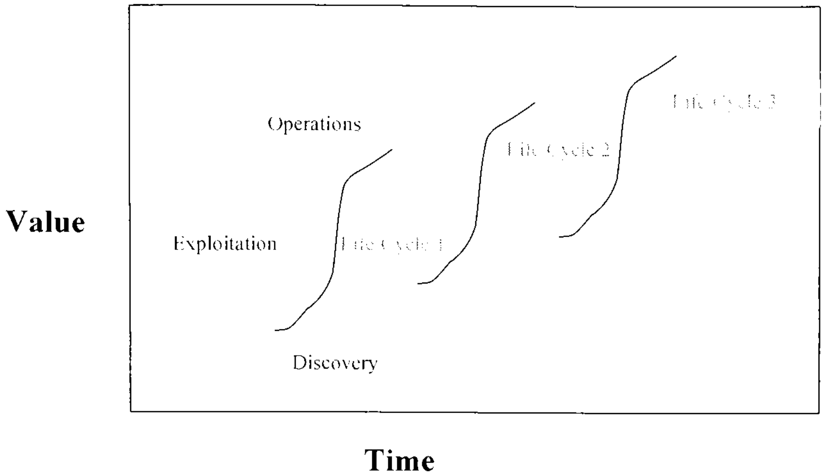


Figure 2.1 – S-curves (Holt 2002)

At the beginning of the life cycle when a technology is discovered, its value potential has yet to be realized. Through product development and commercialization, the technology is integrated into new and unique products that quickly build revenue for the companies that introduce them. This represents the exploitation stage of the S curve. Once the market is established and the major players are fighting over market share, the technology is considered to be in the operations phase. At this point in the cycle, the technology's value expectations will level off and existing market revenue will be fought over by every organization currently in the market.

All technologies have a life cycle and understanding how far to stretch the curve before moving to the next one is an important idea. A successful and forward-looking company will develop a technology strategy that allows 'jumping' from one technology curve to the next at the proper time. Research and development are one part of this transition, but product development is also important. Once a new, useful technology has been developed, it must be integrated into products to create revenue. Value creation comes from understanding when to jump S curves and which curves will yield the most value. A balance must be struck between holding onto and funding current revenue generating products and supporting R&D's search for the next technologies.

Christensen (385-386) argues that depending on the market, a company should make a conscious decision to lead into a new technology or follow competitors. The R&D costs are much higher to innovate, but in some instances the market share gained, and intellectual property protection, are

well worth it. Christensen suggests that most companies would want to be followers for performance competitive markets such as computer components. He also emphasizes that the preferred strategy for a disruptive technology is to be first to market.

Architecture Objectives

The goal of an architecture is to provide a framework upon which a system or product may be developed. The fine-grained architecture should define the function, aggregation and relationship of each partition. Some examples of objectives during the architecture phase are as follows:

The objectives for the architectural design stage:
(Arnold, Brook, Jackson, Stevens 88-89)

- Production of a design that will meet the user and system requirements within the operational environment;
- Definition of the components to be built, the implementation approach and choice of the core technologies to be used;
- Definition of how components interact to generate the emergent properties called for in the system requirements;
- Trade-off between candidate designs to maximize system effectiveness;
- Generation of an integration test strategy consistent with the design structure;
- Partition of design components for allocation to different groups of implementers;
- Definition of the deliverable items (the basis of subsequent management control);
- Estimation of the most likely cost and risk, plus the contingency needed to cope with the risks;
- Ensuring that the design work incorporates the results of previous decisions;

These objectives must be carefully considered at the architecture design phase, as they will have a large impact on the rest of the product or system lifecycle. "Architectural design defines clearly what is to be built. This is potentially the most creative part of the system process, and the point at

which the cost of the system is largely fixed" (Arnold, Brook, Jackson, Stevens 88).

Once the objectives of the system architecture are defined, a systems architect must have a process by which to obtain these objectives. Beam presents the following top-down design process (37):

1. Establish a set of overall requirements or objectives.
2. Divide (decompose) these formally, to define a set of parts or subsystems.
3. Purchase or build the subsystems.
4. Assemble (build) them correctly.

This is a very simplistic model and many companies have further expanded on these tasks to suit their needs. In reality, systems architecting has a number of contributing factors that can lead to multiple design iterations before an optimum is achieved.

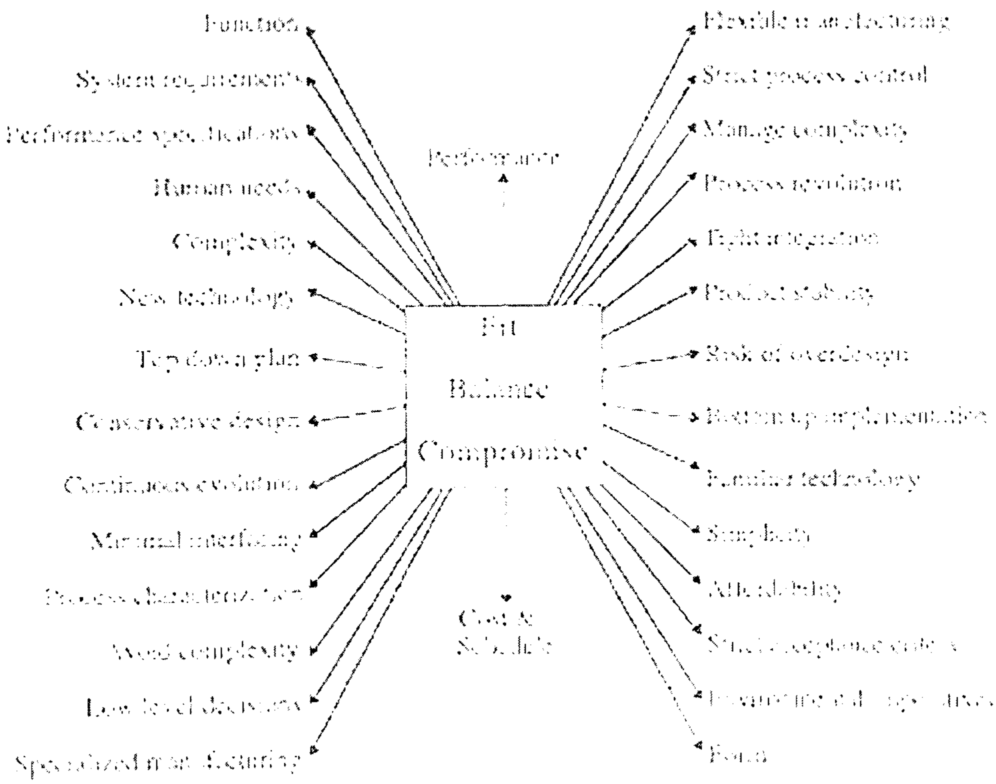


Figure 2.2 – Architecture Pressures (Rechtin 1991)

According to Rechtin and Maier, "Architecting is both an art and a science – both synthesis and analysis, induction and deduction, and conceptualization and certification – using guidelines from its art and methods from its science" (21). Given this relationship between the quantifiable and the intangible, assessing the merits of an architecture can be difficult. Beam (86) provides his assessment criteria:

- It (the Architecture) evidences an overall unity – its parts do not compete but complement one another, and are similar in quality, durability and utility.
- It has no parts which appear to be afterthoughts. Likewise there is little waste in its operation, no duplication of parts except that required to fulfill functional, performance, or reliability objectives.
- It exhibits balance, order, and symmetry from many points of view: e.g., internally (through its structure and organization), externally (through its appearance and its ease of access and use), logically (through design relationships), and functionally (through economy of design, meeting the objectives without waste).
- It has not only a sound top-level scheme but its quality holds up in detail as well – close examination of its parts reveals the same qualities and soundness as does the system as a whole.

These criteria provide a basis for qualifying a system architecture. Keeping these guidelines in mind during the architecture design will also reduce the iterations in the process.

One area of product architecture that is not commonly stressed in any product development model is architecting with an intellectual property strategy in mind. Regardless of the merits of a new product, if it cannot be legally produced without infringement or successfully protected from competitors, it will never reach its revenue generation potential. Given this need, it is important for the organization and its product development teams to understand intellectual property and the impact it has on corporate strategy.

Intellectual Property

"The Congress shall have the power...to promote the progress of science...by securing for limited times to authors...the exclusive rights to their...writings"

-Article I, Section 8, Clause 8 of the United States Constitution

This clause of the Constitution provided the framework from which our intellectual property legislation arose. These laws provide ownership of ideas, legal recourse in the case of infringement, and serve as a major part of our economic system. The ability to protect an idea from competitors gives a company a head start on the commercialization process. As Abraham Lincoln said, "Patents add the fuel of interest to the spark of genius" (as quoted by Glazier 5). Patents present an economic advantage to those who are the first develop new ideas.

There are four main types of Intellectual Property: (Cookfair and Gordon 3-5)

- **Trademarks** – a distinctive word or phrase, name, symbol, or device used to identify the source of the goods in commerce. A trademark on a product serves to identify the manufacturer or seller and to distinguish it from the products of others.
- **Copyrights** – directed to the protection of the creative works of authors, artists, and others from unauthorized copying. Although general related to written works, Congress and federal courts have interpreted copyright laws to include other form of expression such as musical composition, photographs, paintings, and other artistic expressions. Copyright law also protects computer programs. A copyright only protects the expression of an idea, but not the underlying idea itself. Copyrights provide less protection compared to patents.
- **Trade Secrets** – generally relate to confidential information held by a company. Trade secrets do not carry the same legislative protection as other forms of IP. They are not disclosed to the public and fall under the jurisdiction of state governments. Trade secrets rely on non-disclosure agreements between companies and employees or between the owner of the trade secret and any other

entity (university, company, government, etc.) to which the owner discloses the trade secret.

- **Patents** – generally considered to be the strongest form of intellectual property. Patent laws focus on the protection of inventors. A patent is a grant by the government, to an inventor, conferring the right to exclude others from making, using, or selling his/her invention for a limited period of time.

This thesis will focus on patents as the main source of intellectual property. Of the four types of IP, patents are used in most product development cases and relate best to system architecture. Throughout this thesis, the terms 'intellectual property' and 'patents' will be used interchangeably.

Intellectual Property as a Business Strategy

At one time intellectual property was deemed relevant only to the people in research and development and those in the legal office. Recent trends, especially in the high tech market, have lead to a change in those beliefs, and the value that IP holds.

Many companies choose to think of their IP portfolio as an asset. The rights to ideas, processes and techniques give them a competitive advantage when leveraged properly. The following are Glazier's (2-3) five main goals of intellectual property asset management:

1. **Protection of a company's products, services and income.**
   This is the most well known IP strategy consisting of using patents and other forms of IP in a defensive mode. A company seeks to prevent competitors from infringing upon their products through the legal protection that IP provides.

2. **Generating cash by selling or licensing patent rights to others.**
   This model of revenue generation is implemented by many companies who are more comfortable allowing others to assume the risks and problems associated with innovating a new technology into a profitable product.

   IBM is a good example of the revenues to be generated from licensing. Their annual patent-licensing royalties rose 3,300% from

$30 million in 1990 to $1 billion in 1999. An additional benefit to these licensing revenues is the very large return on investment they provide. Once the patent exists, the only costs associated are the maintenance fees. The money provided by the licensing can be considered bottom line profit (Kline and Rivette, Discovering New 4).

3. **Obtaining a legitimate monopoly for future exploitation.** The point of this goal is to put a new technology "on-hold" until a decision is made about how it can best be used (Glazier 2).

4. **Protecting research and development investments.** This strategy is most common where a large investment into R & D has yielded an innovation worth the costs of a patent.

5. **Creating bargaining chips.** A company sometimes develops a large patent portfolio to be used as leverage to negotiate cross-licenses with potential competitors that may, in the future, claim that the company is infringing on the competitor's patents. Again, the motive is insurance, that is, if a company is concerned that another company may sue it for patent infringement; it may wish to trade its rights in its own broad patents for rights to a competitor's broad patents.

The maintenance of patents is also a concern for many organizations. Patents have fees associated with their upkeep and thereby a large portfolio can be very expensive. Companies must make a decision about how much IP they would like to carry and how strongly or weakly to protect individual products. Patents that are not currently being used by an organization are often donated to charity as a tax write-off or abandoned altogether to cut costs.

Before a company can worry about managing its intellectual property portfolio, it must develop it. Traditional thoughts pertaining to the invention and innovation process leads most people to believe that exceptional minds like Edison and Einstein are the sole sources of groundbreaking and patent worthy ideas. This mindset can lead companies to undervalue the process of creating new intellectual property through a focused effort. Glazier feels that successful companies develop intellectual property through a structured process. They then use this IP to create well-protected products that fit a customer need.

Intellectual property relates to product development in two ways. A corporation can develop a technology and patent it with the expectation of creating products, or they can create a product and use IP to protect it from competitors. In many cases the technology patent provides the basis for the product platform, represented by the coarse-grained architecture. The product related patents serve to protect the fine-grained architecture.

Kline and Rivette's IP-3 approach deals with these different types of IP.

The IP-3 Approach to Creating Dominant Products

(Kline and Rivette, Unlocking the 106-107)

1. **Protect Your Core Technology Advantage**: **(Coarse-Grained Patent)**
   Use patent mapping to select products that can be buttressed with competitor-blocking patents, then patent the core technologies embodied in these products that deliver the greatest performance advantage over the rival products in the market.

2. **Reinforce the Product's Differentiating Features**: **(Fine-Grained Patent)**
   Reinforce those core patents with a patent wall of IP protection covering the key differentiating features that reinforce and communicate the product's brand positioning and key performance advantages.

3. **Control the Process Choke Points**:
   Patent the key methods and processes—whether these are manufacturing, distribution, or even business methods—that are absolutely essential to the building, marketing, or selling of the product.

This approach provides an excellent structure for developing a competitive product and securing market share. Glazier, however, presents a method for developing a competing product in a market where a dominant product already exists. The following are his twelve rules of virtual genius. These

rules allow an individual to circumvent a competitor's patent strategy. He calls this process "inventing on demand" (14) which allows for product innovation based on an existing product while avoiding infringement.

12 Rules of Virtual Genius

(Glazier 15-24)

1. Eliminate a Part

The primary secret to inventing on demand is to carefully inspect the competitor's patent and the prior art in the field, and then to invent by eliminating the non-essential elements that were previously thought to be essential.

The basic legal test for infringement is that one of your products uses every element claimed in an independent claim of your competitor's patent. If you manage to develop a way in which the product may be made without one of the claimed essential elements of your competitor, then you may avoid the legal test for infringement.

Where a part cannot be found to eliminate in a competitor's patent, try to find a part that can be structurally changed to the point that it is a different part, even if it may function the same.

If a part cannot be eliminated or structurally changed, then try to find a part that can be changed to function differently, even though it may be the same structurally.

2. Do Not Add Parts

A related rule for inventing on demand and designing around a competitor's patent, deals with analyzing problems in early prototypes. The natural human tendency seems to be to address problems in a product by adding parts and functions. However, it is often better to address problems in prototypes by eliminating or changing parts, not by adding parts.

3. Use a Lean Broad Design Team

This goal of leaner design is best addressed in most corporate cultures with a lean design team. It seems to be an axiom of human organizations that the larger a committee is, the less able it is to develop a focused innovative design.

4. Focus the Product

It is possible to design a device that does one thing very well; however, it is often impossible to design a device that does many things very well.

5. Exploit Components with New Low Prices

Look for components that recently have become dramatically cheaper. Whenever this happens to an item, the item newly becomes a potential practical replacement for other items, or an addition to other items. This activity can constitute a patentable invention and a good new product.

6. Make Old Equipment Smart

Put a computer chip and a keypad on just about anything and you have a platform for the new smart version of the thing. Then find out what the market would like the smart thing to do, and program it accordingly. This can give you a new patentable product.

7. Exploit New Communication Devices and Services

Examine any new communication device or service to see how it enables a further new communication service. Services may be patentable if they represent new processes for delivering the service, especially if some software is involved.

8. Computerize a Previously Manual Process

Computer software and computer algorithms can be patentable. If your company is the first to computerize an old function or process, then your company may be able to patent the concept of the computerization.

9. Use New Materials

New applications of new materials in old devices can lead to superior performance, and patents. For example, the development of lightweight, strong, heat resistant composite fiber materials has led to surprising advances in airplanes, rockets, golf clubs, clothing, and industrial abrasives.

10. Focus on the Software

Software is now clearly candidate subject matter for patents, and lots of software patents are being issued. This amazes many people (and annoys some), but now every new computer program should be considered for a patent, and analyzed for possible infringement of the patens of others.

11. For Software Only: Find New Functions

Software is different from other technologies. Often the uniqueness of the inventive effort in software, smart equipment, or software-hardware hybrids, is more in conceiving new functions for the software than in conceiving how to make it do what it does.

12. Mind the Esthetics

One goal for a new product or service is a good look that ads nothing to a product's production cost, but dramatically increases its sales. A good look can be pure profit. And elements of non-functional ornamental appearance, if they are distinctive, can be protected by something called design patents and trademarks.

Glazier's virtual genius rules provide a tool for evaluating one's own product designs as well as a competitor's. Inspecting a product design using these tools will highlight areas in need of improvement or potential exploitation points.

Summary

This literature review provided a synopsis of relevant research that has been conducted in the fields of system and product architecture and intellectual

property as it pertains to commercial products. Important concepts that were presented in this chapter will be revisited later in this thesis. Of most importance are the ideas of Glazier, Maier and Rechtin, and Christensen, as previously discussed.

Chapter 3. Product Architecture

Product architecture is one of the earliest phases of product design. This section will provide a definition of product architecture, explain fundamental concepts and definitions, describe various tools architects implement and the objectives of an architecture process. The main focus of this product architecture discussion will center on those aspects that have a direct impact on intellectual property.

Definition and Purpose

Product architecture is closely related to systems architecture in that most products can be thought of as systems of varying complexity. Products at a basic level consist of interrelated components and the interfaces they share. The architecture of a product involves deciding which components will be combined into modules and defining the interfaces between modules.

The importance of product architecture is described by Ulrich and Eppinger: "Product architecture decisions have far-reaching implications, affecting such things as product performance, product change, product variety, component standardization, manufacturability, and product development management" (148). The authors feel that the architecting phase of product development is important because it lays the groundwork for the entire life cycle of the product.

Another purpose of architecture is to, "clearly define what is to be built" (Arnold et. al. 88). It is one of the most creative phases of the product design cycle and can be thought of as working with a clean sheet of paper. The decisions made at the architecting phase will have a drastic impact on the rest of the product life cycle.

Concepts and Definitions

A basic concept required to understand product architecture is the idea of domains.

Domain

do main (dō-mān')
n.

1. A territory over which rule or control is exercised.
2. A sphere of activity, concern, or function; a field: *the domain of history.* See Synonyms at field.

...

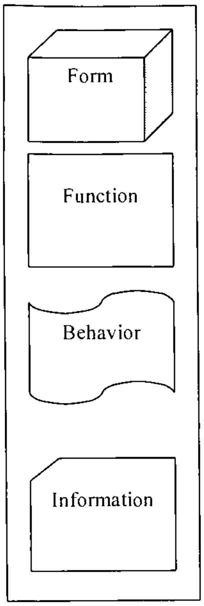
The second definition here holds the most relevance for product architecture. Domains in the architecture world represent a level of thinking, or looking at a product from a different frame of reference. Each frame of reference can be thought of as a different domain. There are three domains of product architecture as described by Erens and Verhulst:

- The **Functional Domain** consists of all the tasks expected of the product, generally in noun-verb form. An example would be "store power" for a power cell.
- The **Technological Domain** is used to describe what technologies will be incorporated in the product to accomplish the functional tasks. An example would be "alkaline 1.5V battery" for the function "store power".
- The **Physical Domain** describes how tasks will be physically accomplished.

Models

In order to examine the product under development in each of these domains, product architects incorporate various product models. These models serve two purposes; they help the architect define the architecture and, at the same time, they provide a documentation and communication tool for shared understanding.

A product architecture can be modeled in four categories (Stiebitz):



Architecture models that deal with form generally serve to describe the product in the physical and technological domains.
Functional models describe the product in the functional domain. They also describe how a user would interact with a product.
Behavior models are used to represent how the product reacts in a sequence or time ordered fashion. Behavior models also describe what relevant states a product can be in.
Information models describe the data and communication flows between a product and its environment as well as between modules within the product.

Figure 3.1 – Types of architecture models

Combinations of these models serve to describe the product and ensure that requirements are met. They can also be used as a forecasting tool to determine possible defects in the system before the product exists.

Another important concept in product architecture is modular design.

Module

From *The American Heritage® Dictionary of the English Language, Fourth Edition:*

mod ule (mŏj'o͞ol)

n.

1. A standard or unit of measurement.
2. *Architecture.* The dimensions of a structural component, such as the base of a column, used as a unit of measurement or standard for determining the proportions of the rest of the construction.

3. A standardized, often interchangeable component of a system or construction that is designed for easy assembly or flexible use: *a sofa consisting of two end modules.*

The third definition of module holds the most relevance to product architecture. A well thought out modular design provides the necessary level of flexibility for the product. A physical modular design consists of standardized interfaces that allow for interchangeable parts. Modules generally perform a single function or a few highly related functions.

Interfaces

Most modular designs achieve their flexibility through interfaces, which are connection points, either physical, informational, or both.

An example of a modular design would be an IBM type personal computer. The design is such that almost all external components (mouse, keyboard, monitor, etc) are interchangeable and share standardized interfaces.

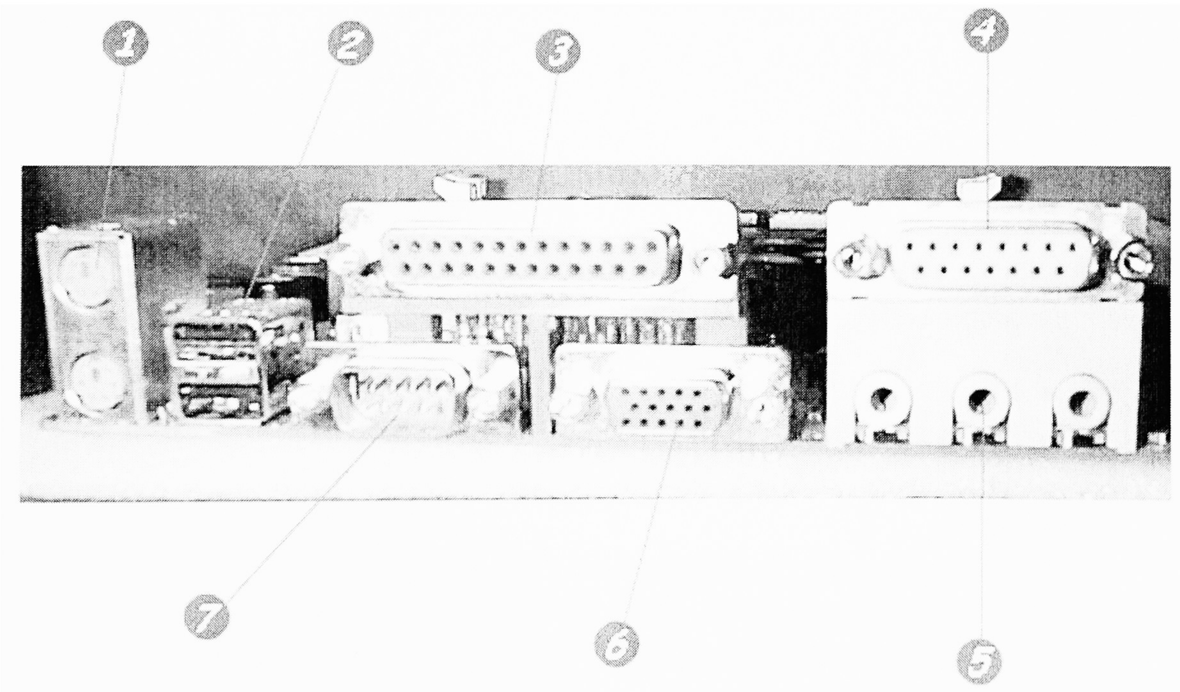


Figure 3.2 – Motherboard modularity

The image[1] on the previous page showing the connections on a motherboard shows many common device interfaces. The item labeled number 1 is a PS2 port which is an industry standard for connecting to a keyboard or mouse. Item number 2 is a USB port for connecting a number of various devices such as a printer, scanner, or camera. Items 3 and 6 are serial ports; one being a 15-pin connection and the other a 9-pin. Item 4 is parallel printer port used for both printers and some scanners. Item 5 is a mini jack used to interface to an onboard sound card. Item 7 is an SVGA port that connects to a monitor.

All of the interfaces are standardized across the industry. A consumer can unplug a PC component and replace it with a model from a different vendor of their choosing. In this way each external component of the PC is an interchangeable part.

Open Architecture

An open architecture must meet the following interface criteria (Bass et. al. 381):

1. Fully Defined
2. Available to the public
3. Maintained according to group consensus

Open architectures provide a "level playing field" approach to development. Anyone is free to learn about the design in its entirety, and no one body has the right to redefine components of the architecture.

According to Bass et. al. (381-382), the benefits and weaknesses of open architectures are:

+ **Reduced reliance on proprietary products.** The consumer has a variety of choices from which to make component decisions and no one supplier will be able to gain significant power over the market.

[1] http://www.pantherproducts.co.uk/Articles/images/Motherboard%20ext.jpg

+ **More competition leading to lower cost (and better products).** Choices in the marketplace for the consumer force suppliers to compete on cost, quality, reliability and other factors.
+ **Better-tested products.** A larger number of users are available to field test products and find problems.

– **Failure to meet performance requirements, environment requirements, and so on.** Separate components generally mean separate design teams and may result in reduced performance for the final product due to lack of communication and combined testing.
– **Conformance and certification problems.** Assuring that all involved parties adhere to the agreed upon interface parameters can be difficult.
– **Support problems.** Vendors not responsible for an entire system may "pass the buck" for failures they claim they are not responsible for.
– **Continued investment.** Individual components may have separate life cycles and upgrades may prove necessary regardless of consumer preference.

Leader firms are likely to take open architecture concerns into account when developing new products. They will want to protect their innovations, but the pros and cons of an open architecture will lead to difficult architecting decisions.

Process

Due to the creative and unique nature of product architecting, there are many different methods employed throughout the discipline. Some companies have particular guidelines for defining product architectures within their product development process, while others may use less formalized means.

Rechtin and Maier (30) present the following steps in an architecting process:

- Scoping and planning
- Modeling
- Prioritizing

- Aggregating
- Partitioning
- Integrating
- Certifying
- Assessing
- Evolving and rearchitecting

Rechtin and Maier continue in their discussion of each phase in the process, but the aim of this thesis is to relate architecture to intellectual property. Given this priority, the rest of this section will review the steps in the architecting process that have the greatest impact on IP.

Scoping and planning

The scoping phase of product architecting is used to define exactly what the product development process is to produce. Scoping defines both what is in the system's control and what it outside (Rechtin, Maier 146). An architect must determine what it is the customer wants during the scoping phase. The remaining seven steps will assure that those wants or requirements are fulfilled. Two heuristics that Rechtin and Maier (147) point to that illustrate this idea are as follows:

- The most important single element of success is to listen closely to what the customer perceives as his requirements and to have the will and ability to be responsive. (J. E. Steiner, 1978)
- Success is defined by the beholder, not by the architect.

Modeling

The modeling phase of the product architecture process is one of the most important. It is at this phase where the architect "acts to translate between the problem domain concepts of the client and the solution domain concepts of the builder" (Rechtin, Maier 115). In this sense, the architect provides vision and structure for the entire design process.

Rechtin and Maier state that the following six roles must be satisfied during the modeling state of the architecture process (120):

1. Communication with client, users, and builders;
2. Maintenance of system integrity through coordination of design activities;
3. Assisting design by providing templates, and organizing and recording decisions;
4. Exploration and manipulation of solution parameters and characteristics; guiding and recording aggregation and decomposition of system functions, components, and objects;
5. Performance prediction; identification of critical system elements; and
6. Providing acceptance criteria for certification for use.

Aggregating and Partitioning

This phase of product architecting involves "grouping and separating related solutions and problems" (Rechtin, Maier 148). Partitioning is the process of separating elements through the physical, functional or technological domain while aggregating is bringing like elements together. Generally these two processes are related in such a way as both are done simultaneously. Rechtin and Maier (146) list six tasks to be completed during this phase:

1. Behavioral-Functional Decomposition,
2. Physical Decomposition (to lower level design),
3. Performance Model Construction,
4. Interface Definition / Analysis,
5. Decomposition to cyclic processes, and
6. Decomposition into Threads.

Rechtin and Maier (148) also point to two useful heuristics for this phase of product architecture:

- In partitioning, choose the elements so that they are as independent as possible, that is, elements with low external complexity and high internal cohesion.
- Group elements that are strongly related to each other, separate elements that are unrelated.

Integrating

The integration phase of product development entails the design of the physical, functional, and communication interfaces between 'chunks' developed in the aggregating and partitioning phase. Beam (9) calls this "The most severe test of the quality of the systems engineering."

Bass, Clements and Kazman (84-85) explain that integration depends on "external complexity of the components, their interaction mechanisms and protocols, and the degree to which responsibilities have been cleanly partitioned."

Assessing

Assessing an architecture depends on the original goals defined in the scoping and planning phase. This step in the process, as described by Bass et. al. (225), allows architects to validate original requirements. Questions about how well the architecture meets the goals of the system or product must be addressed during this phase.

Architecture and IP

To develop a successful commercial product, intellectual property concerns must be addressed at each process stage described in this chapter. When done correctly, product architecture provides a framework for designers to begin their work. This foundation must be structurally sound from a number of different perspectives.

The next section of this thesis will synthesize some of the ideas presented from this chapter as well as chapter 2. Chapter 4 will introduce a process used to aid organizations effectively assess and develop product architecture with intellectual property strategy in mind.

Chapter 4. IP / Architecture Process

This section of the thesis will describe a synthesis (Figure 4.1) of existing ideas into a decision making tool. The IP / Architecture process involves Glazier's 12 rules, Rectin's architecture development process and an architecture examination piece involving ideas from Erens, Verhulst, and Stiebitz.

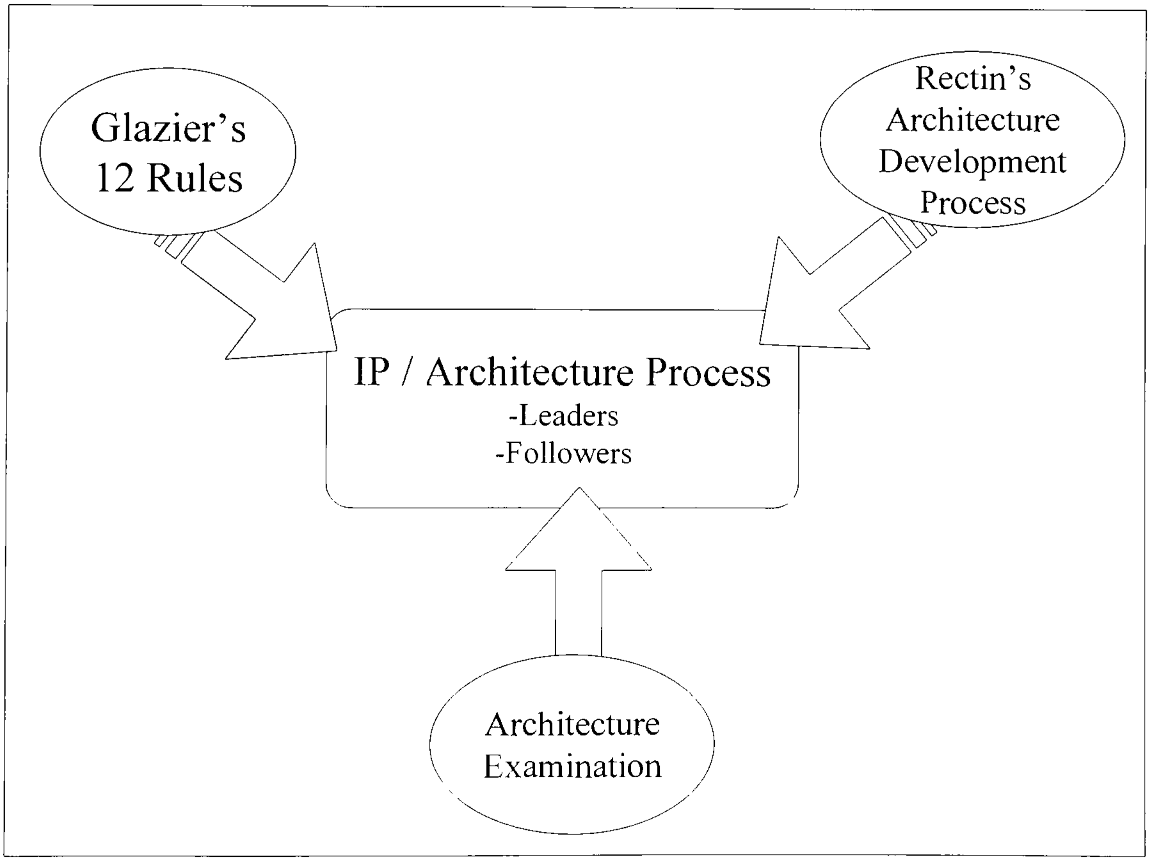


Figure 4.1 – IP / Architecture process synthesis

The process is further broken down into guidelines for leader organizations as well as follower organizations. This distinction is explained in the next section.

Leaders and Followers

Recall the ideas of Christensen from the literature review section of this document. He described two types of organizations. The first being leader organizations that rely heavily on research and development to come up with new ideas for commercialization. The others are follower organizations that wait to enter a market until the leaders have already proven it to be successful. Leaders spend larger amounts of capital on research and therefore take bigger risks. However, being first to market affords them a head start on claiming market share.

Economic laws dictate that where there is a profit to be made, firms will attempt to enter the market. Followers generally significantly outnumber the leaders in a given market and do anything they can to try to win customers away from the leaders.

For any given technology or product platform, both leaders and followers have to make a number of decisions. These decisions will be broken down into two different categories: the opportunity phase, and the implementation phase. The opportunity phase for leader organizations differs from that of followers and will be discussed separately. The implementation phase is common for both types of organizations.

Opportunity Phase

The opportunity phase involves a firm's decision about how to earn revenue with a given technology. For leader organizations, this stage begins with the discovery of a new technology. Follower organizations begin by examining existing technologies for opportunities.

Opportunity: Leaders

The main goal of the opportunity stage for leader organizations is to determine the best way to position a new technology in order to earn revenue. Decisions must be made about how to go to market, when to go to market, and whether or not to go to market at all. The management of leader

organizations must also decide what type of intellectual property strategy to use with their new technology. This stage of the process involves decisions that will dictate coarse-grained product architecture choices as was discussed in the literature review. The following graphic describes the steps in this decision process for a leader organization.

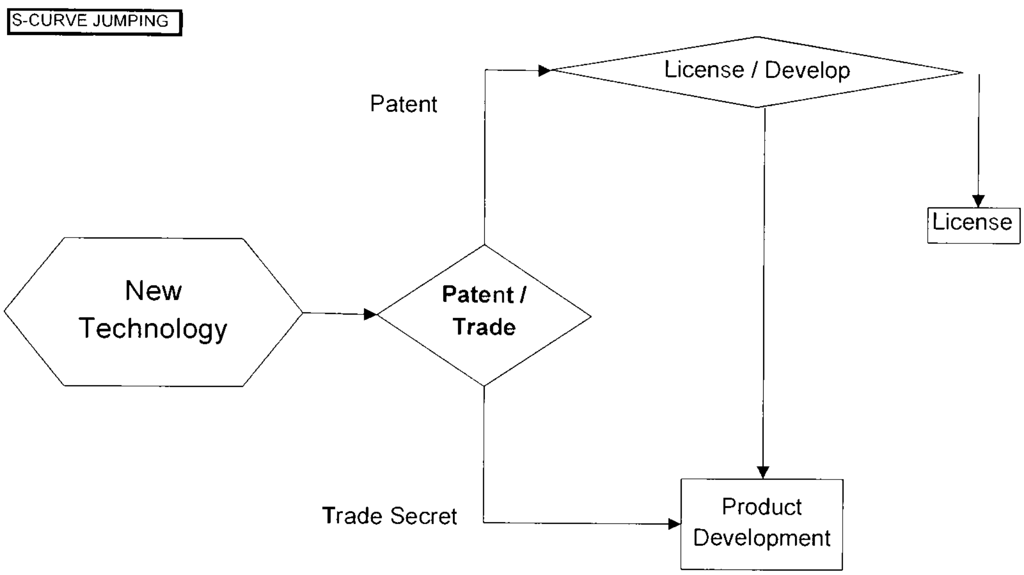


Figure 4.2 – Opportunity phase for a leader organization

One of the first decisions a leader firm must make after the discovery of a new technology is what form of IP protection to use. For most technologies discovered through a research and development process the choices are patent or trade secret.

As discussed in the literature review patents provide the strongest form of legal protection. However, they also require public disclosure, meaning the idea is fully described in patent literature available to anyone. This can provide competitors with blueprints for creating similar products.

Trade secrets, on the other hand, offer very little legal protection. They rely on non-disclosure agreements made between companies and employees or between the owner of the trade secret and any other entity (university,

company, government, etc.) to which the owner discloses the trade secret. In some cases, trade secrets are a very effective IP protection strategy, but they provide little legal recourse.

After an IP strategy decision has been made, a leader organization must decide the best way to earn revenue. In the case of the patent decision, a firm can either license their new technology, or commercialize it through product development. Depending on the technology, licensing can be an attractive option. As was noted in the literature review IBM generated $1 billon in revenues in 1999 from licensing alone (Kline and Rivette, Discovering New 4). In the case of a trade secret decision, the only way to earn cash flow is with product development.

As was stated before, the decision process for leaders in the opportunity phase influences the product architecture stage of product development. Theses choices will reflect how technologies are delegated into product families and what platforms they will be based on.

Opportunity: Followers

The opportunity phase for follower firms differs from that of leaders in that the technology to be developed already exists. Follower firms are concerned with producing products based on existing ideas. In order to do this they must first determine if there is a legitimate opportunity. The final result of the opportunity stage for follower firms is a decision to develop a product or do nothing.

Figure 4.3 describes the opportunity decision process for follower firms.

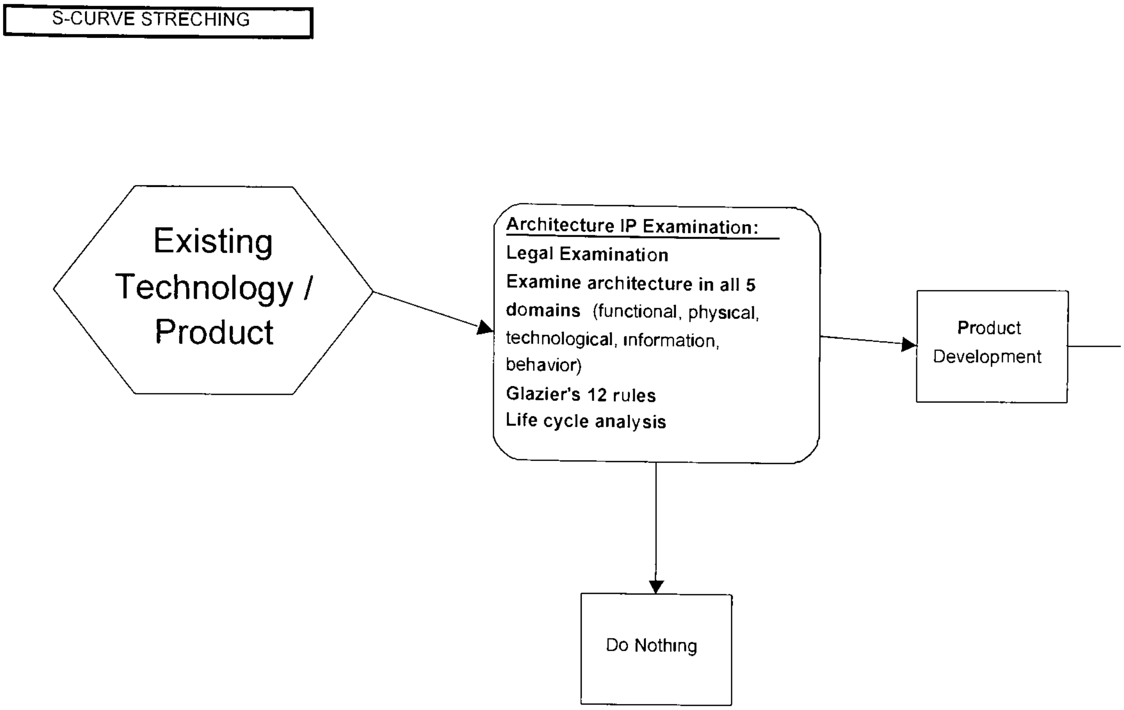


Figure 4.3 – Opportunity phase for a follower organization

Once an existing technology or product has been identified as a possible opportunity, it must be examined. The examination will determine if it is legally possible to commercialize a new product based on the current product or technology.

Legal Examination

The first step in the examination is a legal review. This entails a complete patent mapping of the technology or product in question. A patent map consists of a 'chain' of patents that all relate to a specific technology, or the map serves as a technology timeline and describes exactly who developed what and when. The patent search should encompass technology patents, design patents and process patents.

There are a number of software tools[2] to aid in the mapping process. These tools search the patent databases and provided a structured technology map automatically.

[2] A listing of software tools can be found here: http://www.ipmenu.com/ipsoftware.htm

This patent review process will provide two main benefits. The first is to show what opportunities exist legally for a corporation to enter a market. The second is to provide an understanding of the designs in place. Patents often times can act as a blueprint for a product. Detailed design drawings are often included in the literature as well as a description of how the device works. This understanding will provide the foundation for the next step in the process.

Examine Architecture

Once the patent mapping is complete a firm should try to fully understand all products in the market with which they hope to compete. This will enable the firm to find opportunities based on existing commercial solutions. To complete this stage of the opportunity phase, a follower firm must document and explore the three dimensions of product architecture for a target product, recall those dimensions are functional, physical, and technological.

The functional architecture describes what a product does, the physical describes how it does it and the technological describes what components are used. Stiebitz presents two other aspects of a product architecture: behavior and information.

Using architecting tools, a product's architecture can be explained in each dimension, as well as within the realm of behavior and information:

Dimension	Architecting Tool
Functional	FAST (Functional Analysis System Technique)
Physical (Form)	ABD (Architectural Block Diagram)
Technological	ABD (Architectural Block Diagram)
Behavior	FFBD (Functional Flow Block Diagram)
Information	AFD (Architectural Flow Diagram)

Figure 4.4 – Architecting dimensions and related tools

A FAST diagram is used to break down top-level functions of a product into design choices. For example it would explain the thinking behind utilizing a cathode ray tube (design choice) to display an image (top level function).

An ABD diagram shows the "chunking" of a product. It looks like a hierarchy diagram describing what components fall within which subsystems.

A FFBD shows the relationships between functions within a product. It provides a logical sequencing. For example a cell phone does not ring until it is aware of an incoming call. This order of functions distinction would be described in a FFBD.

An AFD is similar to an ABD in that it shows the product as chunks of subsystems, however the "flow" aspect describes the internal communications of the system.

Defining and understanding an existing architecture allows a firm to determine if there is a potential to develop a new product using the following tools.

Apply Glazier's 12 Steps (Condensed)

Recall from the literature review Glazier's (15-24) twelve steps. He describes a method for "designing around" a competitor's product. Using his method a firm may be able to develop a new product based on a current one while not infringing on any of the IP that the competitor owns. Specific steps from Glazier's process relate directly to product architecture choices. These steps will be discussed in greater detail next.

Eliminate a Part

According to Glazier, the first step in a redesign process is to examine an existing product and look for an opportunity to remove a part. Inspect the physical architecture previously defined and attempt to remove specific components while maintaining the overall functionality of the device.

Focus the Product

An existing product that is "over-functional", or "over-performing" may be less attractive to consumers than a product aimed to meet their most significant need. The architectural analysis from the previous step in the process may identify areas of possible improvement for the functional domain.

Exploit Components with New Low Prices
Make Old Equipment Smart
Exploit New Communication Devices and Services
Use New Materials

For our purposes, these four rules can be combined into a single rule involving the analysis of each individual component with the goal of finding a better alternative. "Better" in this sense would be anything cheaper, smarter, more functional, or in any economical sense preferable.

The architecture models from the previous step in the process can be used to complete this examination.

Life Cycle Analysis

The final step in the opportunity phase for follower organizations is the life cycle analysis. Current solutions for the target market must be examined for opportunity at various stages of their life cycles. It may be impossible to produce a competitive product because of legal or financial reasons at one point in the cycle, but perfectly viable at another.

Many times an organization will place an artificial end of life constraint on their products, for example, single-use cameras. The single-use camera provides convenience for the user, however, it is not completely devoid of value once the single roll of film is exposed.

At the end of the opportunity phase enough analysis is available for follower firms to determine if there is an opportunity to go to market or if the risks are too great and the potential gains too small. If the decision is made to begin the product development process both leader and follower firms will continue to the implementation phase.

Implementation Phase

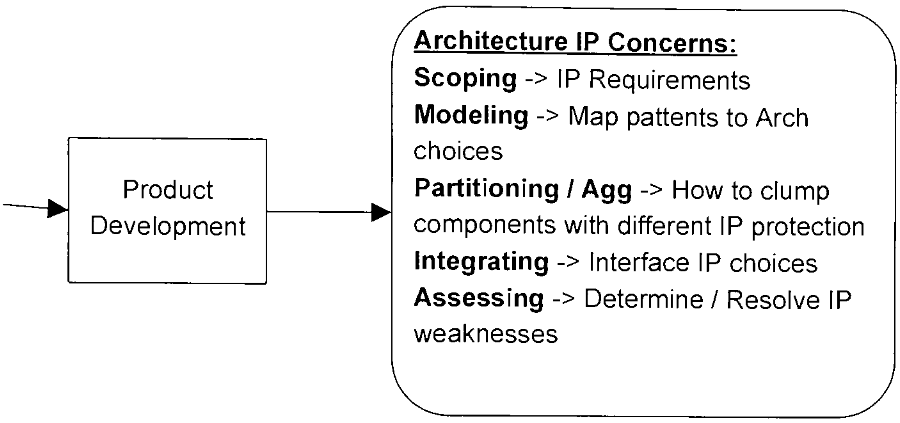


Figure 4.5 – Shared Pre-Concept phase

The implementation phase is based on the product architecture process (Rechtin, Maier 30) discussed in the previous chapter. There are five steps within the process during which intellectual property can be greatly leveraged. These steps are scoping, modeling, partitioning and aggregating, integrating and assessing. Each of these steps has a direct tie in to IP interests. The goal of the implementation phase is a product architecture that provides maximum IP protection while meeting all customer expectations.

The steps of the implementation phase are identical for both follower and leader organizations and begins when the decision to develop a new product has been made. However, the decision criteria involved is different for each type of firm. Leader organizations are concerned with developing a sound IP architecture that will protect their product from "knockoffs." Follower organizations, on the other hand, are trying to produce "knockoffs" to compete with current products. They must assure that the new product does not infringe on any existing product while still offering something of value to the consumer.

The next section of this chapter combines pieces of Rectin and Maier's system architecture process with IP strategy concerns. Each of five steps to creating well-protected product architectures are outlined.

Scoping

The scoping phase of the product architecture process provides clear direction and purpose for the product development endeavor. It is imperative that everyone working on the project understands how IP decisions made by the organization during the opportunity phase will impact future work.

Architects at this stage should ensure that the IP strategy chosen for the particular product is translated into design (or customer) requirements that other members of the product development team will understand. For example, if a particular patent claim must be invented around, it should become a design requirement at this stage.

This stage of the process is very important because decisions made at this point will define not only the architecture to be developed, but also the business opportunity. By setting a product's scope, individuals are providing vision and defining the design and business challenges they want answered at the end of the process leaving all the possible solutions still available. While scoping entails some degree of restraint, it also is largely an exercise in design freedom.

Modeling

Keeping IP priorities in mind during the modeling stage is of utmost importance. It is at this stage that architects have the biggest influence over the final design. Stakeholder requirements must be translated into design criteria and communicated effectively.

An architectural model can be the basis for describing differences and similarities between like products. Models can be used to describe all domains of a product's architecture. If a follower organization's goal is to emulate a current product in the functional domain, this can be expressed during the modeling stage. If, based on Glazier's twelve rules, components

from an existing design are to be replaced, it should be reflected in the physical architecture models, such as architectural block diagrams. For a follower organization it is imperative to separate their new product from existing products at this stage.

The modeling phase also allows for the examination of a product relative to the IP available. All relevant functions and components of a product should be mapped to the intellectual property assigned. If a key component or function is not protected, it should be a warning sign to the firm.

Partitioning and Aggregation

This stage in the architectural process plays a direct role in terms of open and closed systems. A relevant concern for the partitioning of a product should be the intellectual property in question. It is to be expected that not all functions a product provides will fall under the same patent, or in some cases be patented at all. The goal of this stage is to separate functions and components based on a logical IP scheme. Core competencies covered by tight design patents should be separated from less important functions.

Integrating

During the integration phase of product architecture intellectual property strategy dictates the type of system to be used. An open product would have well defined interfaces that enable modularity while a closed system is more likely to be tightly coupled and cohesive. Sound business and strategy decisions will dictate what degree of openness is correct for each type of product, but the architecture must reflect the choices made.

Assessing

At the assessing stage, architects should review their designs in an attempt to find weaknesses. Using the same format as the opportunity phase for follower firms, organizations should try to "invent around" their work-in-process products. Using similar tactics that competitors are likely to try will improve the current design. This step is beneficial to both leader firms as well as follower firms. Once the follower firm releases their first product

into a market place, they will take on some of the characteristics of a leader firm in that their ideas and products will become fair game for the rest of their competitors to try to copy and improve upon.

Conclusion

The process outlined in this chapter is meant as a guide for incorporating intellectual property strategies into the early stages of new products. Firms were characterized as either ground breaking leader organizations or followers. The discussion illustrated how each type of firm can make decisions about going to market and choosing an IP strategy. Lastly, specific steps of the architecting process were related to IP concerns.

This process is intended to be a general overview. Some of the related issues to intellectual property have been underemphasized due to the focus of this thesis. Patent upkeep and litigation can be very expensive and firms must make wise decisions about which products should be protected and to what degree. Furthermore, companies must make sure to scan the current patent literature on an iterative basis in order to stay on top of competitors' strategic actions.

A further aspect of patent strategy is building a bargaining base. In today's business world many organizations use intellectual property as a means for barter. In order to break into specific markets a firm must have a significant amount of IP to trade.

The next chapter will discuss how this process can be applied to a real life example. The development of a case study involving ink jet cartridges will underscore the importance of considering intellectual property when designing new products. In the first of two case studies, a firm by the name of Repeat-O-Type Stencil Manufacturing Corporation will be portrayed as a follower organization. The study will show how they were able to produce a successful product based off of a Hewlett Packard design.

The second case study will show how the process developed in this chapter would work for a leader organization. A product architecture will be developed for a fictitious company named Chunxil Technologies based on a research initiative currently underway at the Rochester Institute of Technology.

Chapter 5. Case Study

ROT VS HP

Introduction

The case presented in this chapter provides an example of how the product architecture process outlined in the previous chapter can be applied in actual situations. This case is based on a legal dispute between the Hewlett-Packard Company and Repeat-O-Type Stencil Manufacturing Corporation, Inc. In the mid 1990's Repeat-O-Type built a business model around the remanufacture and resale of single use HP ink jet printer cartridges. HP's initial lawsuit claimed ROT infringed on twelve of their patents. The US federal court of appeals eventually dismissed the case in 1997, finding that no HP patents were infringed. The full legal case summary can be found in Appendix A.

This case study will be written from the perspective of Repeat-O-Type as a follower firm. It will begin at the point in the process where HP already has ink cartridge designs and is marketing them to consumers. After a brief introduction to the HP products, this section will include an examination of HP's design that follows the process laid out for follower organizations in the last chapter, viz.:

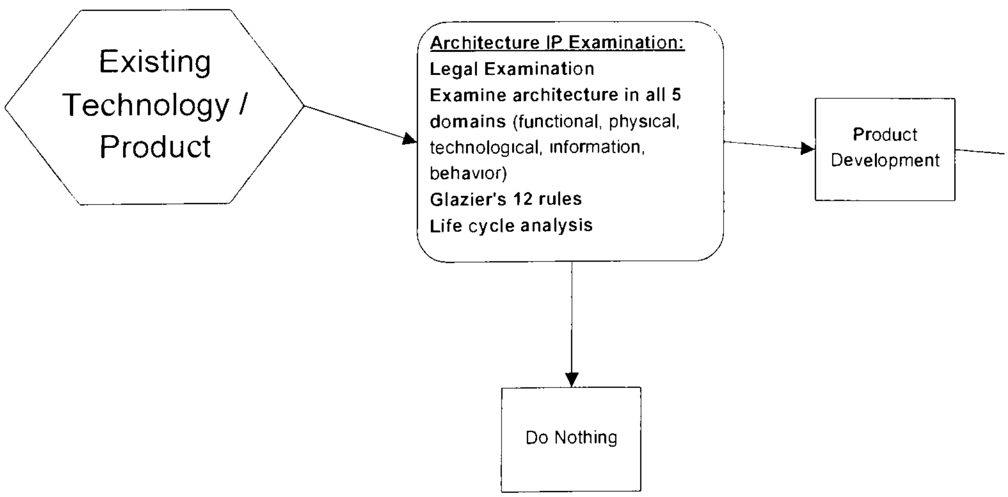


Figure 5.1 – Pre-Commercialization phase for ROT

HP Cartridges

HP's business model for ink jet printing relied heavily on consumables. The printer hardware was sold on very low margins while the profits were expected to come from refill cartridges. A critical point for the success of this model was that cartridges would be single use. Instructions were placed in the packaging, as well as within owner's manuals distributed with the products, that warned of damages resulting from attempts to refill the cartridges. Users were also instructed to "discard empty cartridge immediately."

The two cartridges that relate to this case are model HP 51625A (known within HP as the "Kukla" cartridge) and model HP 51608A (known within HP as the "Stanley" cartridge). The Kukla model is a color cartridge that has three ink reservoirs for the three primary colors. The Kukla image, shown in Figure 5.3, comes from US Patent # 5408256. It shows reconfigured components installed by ROT to make it refillable (items 28, 30, 32, 34). The Stanley cartridge has a single reservoir that holds black ink. The Stanley image shown in Figure 5.2 comes from US Patent # 4931811 and is in its original form.

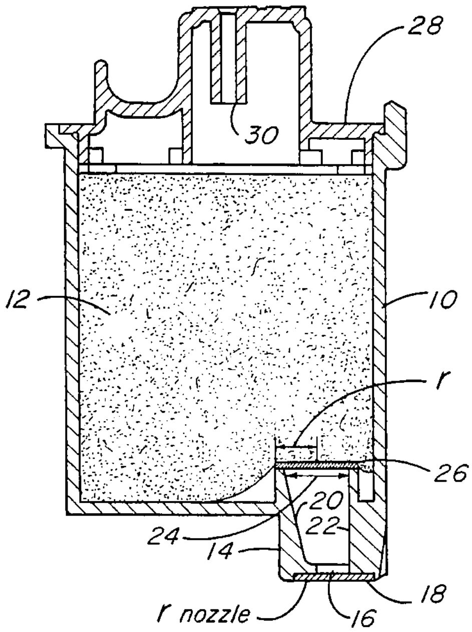


Figure 5.2 – Stanley cartridge

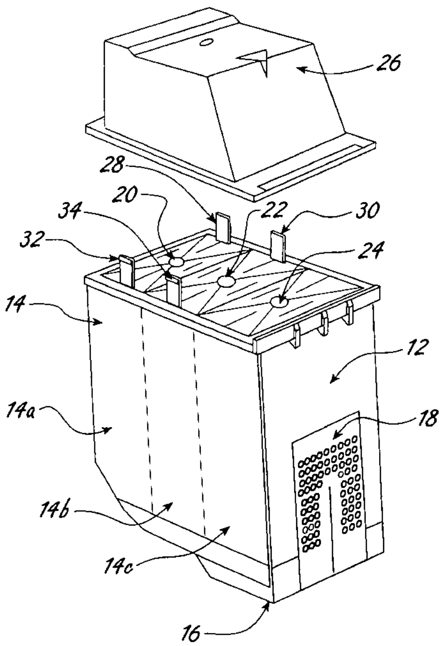


Figure 5.3 – Kukla cartridge

Stanley:

10) Pen (Cartridge) Body Housing
12) Ink Storage Material
14) Printhead Support Section
16) Printhead Opening
18) Thermal Ink Jet Printhead
20) Printhead Support Section Wall
22) Printhead Support Section Wall
24) Standpipe
26) Wire Mesh Filter
30) Air Vent Tube
28) Pen Cap

Kukla:

26) Protective Cap
12) Main Body
28) Post
30) Post
32) Post
34) Post
14a,b,c) Ink Chambers
16) Ink Dispensing Orifice
18) Printer Circuit Board
20,22,24) Air Vent / Refill Holes

These cartridges are the result of a product development process at HP that aimed to take ink jet printing innovations and package them into consumer products. The next section of this chapter examines the architecture and the intellectual property that defines these HP products.

Architecture Assessment

According to the process developed in Chapter 4, HP should have conducted a careful assessment of their own product architecture for potential weaknesses. The assessment done should have mirrored the type of examination a follower organization would undergo. The ROT redesign of HP cartridges is an example of how the IP / Architecture process could be used by a follower organization to enter a market. Whether ROT used a formal process to create their products is unknown, but the rest of this case is written as if ROT had been working through the process for followers in order to develop their refillable cartridges.

Legal Examination

Before attempting to invent around an existing design, a follower organization must conduct a thorough legal examination of the existing technology or product. In this case Hewlett Packard was one of the initial companies to develop ink jet technologies and holds a number of related patents. All of the following patents were involved in the legal dispute between ROT and HP:

- 5,108,503 ink formulation;
- 4,827,294 and 4,931,811 ink jet cartridges;
- 4,347,524 shock absorption of an ink supply tube;
- 4,635,073 thermal print head;
- 4,683,481 thermal resistors in substrate;
- 4,771,295 process for filling an ink jet cartridge with ink;
- 4,794,410 thermal resistor structure;
- 4,794,411 ink propulsion from print head;
- 4,812,859 multi-chamber ink jet pen;
- 4,862,197 - thin-film-resistor print head; and
- 4,872,027 printer and ink jet print head and their interconnection.

It is ROT's responsibility to understand all of these patents and their implications on design. Furthermore, other companies may hold relevant patents that may be important to future ROT designs. The specific legal weakness that ROT exploited will be discussed later.

HP Architecture Models

This section of the case study examines the architecture of the HP cartridges in various dimensions. Recall from the previous chapter, the following tools can be used to define the architecture.

Dimension	Architecting Tool
Functional	FAST (Functional Analysis System Technique)
Physical (Form)	ABD (Architectural Block Diagram)
Technological	ABD (Architectural Block Diagram)
Behavior	FFBD (Functional Flow Block Diagram)
Information	AFD (Architectural Flow Diagram)

During the course of development of HP's entire line of ink jet printing technology, each of these dimensions of architecture played an important role. This case study examines a single piece of a larger overall architecture and thereby some of the above dimensions are not relevant to ink cartridges in the scope of this exercise. The lessons learned from the legal proceedings involving Hewlett Packard and Repeat-O-Type are most apparent in the functional, physical, and technological domains of ink cartridge architecture. The behavior and information domains would relate more to how ink cartridges interact with printers and the information and commands that flow between them.

The following pages describe the functional, physical and technological dimensions of the HP ink cartridge family.

Functional Domain

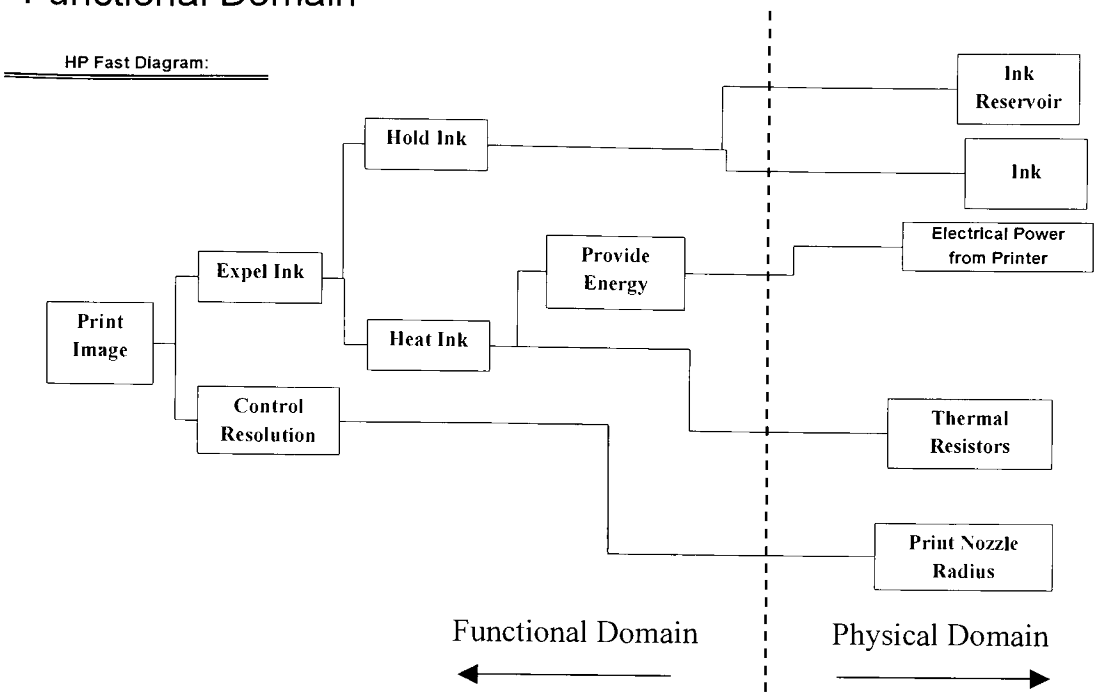


Figure 5.4 – HP FAST diagram

The above FAST (Functional Analysis System Technique) diagram represents the choices that HP made during their development of ink jet cartridges. The left side of the diagram shows the top-level function of the device. This function is broken down into enabling functions until finally being traced to physical design choices on the far right side of the diagram.

The primary goal of an ink cartridge (in combination with an ink jet printer) is to print an image. In order to accomplish this, there must be both ink and resolution. The resolution is controlled partially by the print nozzle design. Likewise, additional design choices are made to satisfy the other functions.

Physical / Technological Domain

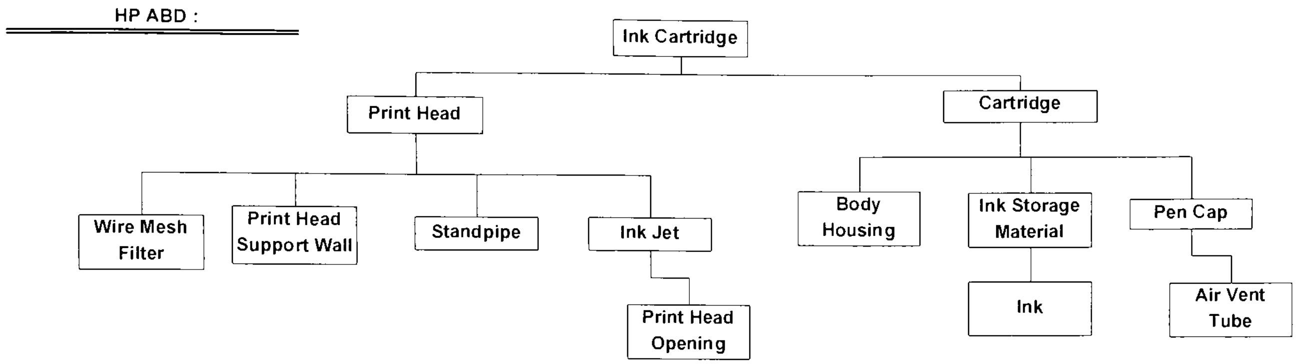


Figure 5.5 – HP Architectural Block Diagram

The HP architectural block diagram (Figure 5.5) shows specific physical components implemented in the design. Many of the components referenced in this diagram can be seen in Figure 5.2 and Figure 5.3. For example, the ink storage material shown under the cartridge module is item 12 in Figure 5.2.

HP completed their product development process and released a family of ink jet printing products. Based on the amount of IP they had acquired, they likely concluded that their business was well protected from competitors.

The following section of this case shows how ROT would implement the IP / Architecture process for follower firms, specifically by breaking down an existing architecture and exploiting IP or architecture weaknesses to develop a competitive product.

Glazier's 12 Rules (Condensed)

Eliminate a Part

Glazier suggests that when attempting to invent around a design, the first thing a follower firm should do is to explore part elimination. Because ROT was trying to penetrate a specific market they needed to ensure that whatever product they developed was compatible with existing HP printers. This would make removing parts of the HP design rather risky.

Focus the Product

This rule pertains to insuring that the product meets the primary customer requirement. Both the Stanley and Kukla cartridges are consistent with the FAST diagram in Figure 5.4 and appear to be focused.

However, this rule also gives an opportunity to look outside the particular product's main function. The primary reason people buy ink jet printers is to reproduce digital documents and images in a physical form. Ink jet cartridges are a facilitating component of ink jet printers. Consumers generally look for a cost to performance trade-off in products they buy. This means that an ink jet cartridge that "prints images" better or in larger quantity than the product sitting on the shelf next to it is likely to be a better candidate for purchase.

Repeat-O-Type's cartridge was designed to provide more copies per dollar invested as described in the '256 patent: "By making the upper protective cap removable the cartridge ink supply can now be replenished up to 10 times before the printhead wears out. This permits up to 2500 color copies now being made with a single cartridge, as compared to up to 50 copies with the non-refillable cartridge."

The refillable feature added by ROT potentially improves the product enough to win customers away from HP's products. However, it must be legal to produce. Other legal aspects of ROT's redesigned cartridges will be discussed in the next section.

Exploit Components with New Low Prices
Make Old Equipment Smart
Exploit New Communication Devices and Services
Use New Materials

The above four rules pertain to replacing components of the existing design with better materials or technology. Using the architectural block diagram as a guide (Figure 5.5), a follower organization can highlight candidate components for upgrade. In this particular case, ROT wants to ensure that its product is fully compatible with HP's models. ROT did not swap any HP materials because they were producing a remanufactured product, and therefore, it would have been more expensive to replace already existing parts.

Life Cycle Analysis

The final piece of the IP / Architecture examination process is the life cycle analysis. In many instances there is revenue to be earned from a particular product even after it is considered exhausted. Figure 5.6 shows the HP timeline for their ink jet cartridges life cycle.

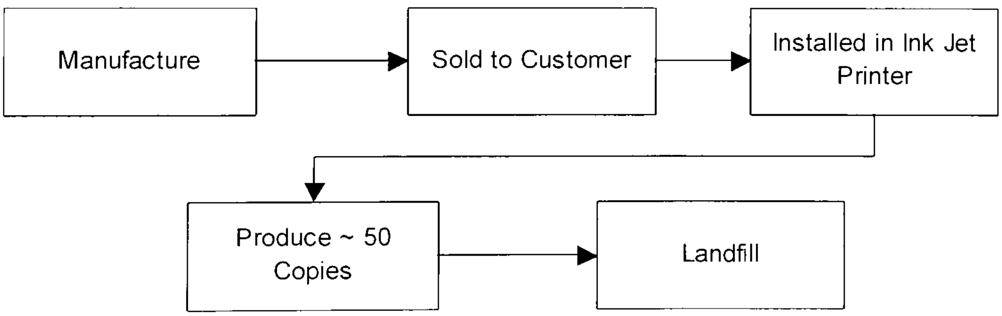


Figure 5.6 – HP life cycle analysis

Based on this life cycle, Repeat-O-Type saw the potential to compete with HP after HP had deemed its product's life cycle was over. ROT analyzed each component of the HP product and determined that, with minor adjustments, they could be refurbished as refillable ink cartridges.

ROT's Invent Around Solution

The architecture and IP examination discussion in the previous section suggests two things. The first is that a business opportunity did exist for building off of HP's ink jet cartridge products. ROT could potentially make money by offering customers a compatible ink cartridge that would provide a longer total life and more copies per dollar. Second, from the patent examinations of HP's intellectual property holdings, ROT was convinced that they had legitimate rights to refurbish and replenish HP ink cartridges, and then sell them to consumers.

ROT Architecture Models

The Repeat-O-Type product architecture models are nearly identical to HP's because they are built off of HP designs. However, ROT made a number of significant changes to the HP functional and physical architectures, as illustrated in Figures 5.7 and 5.8.

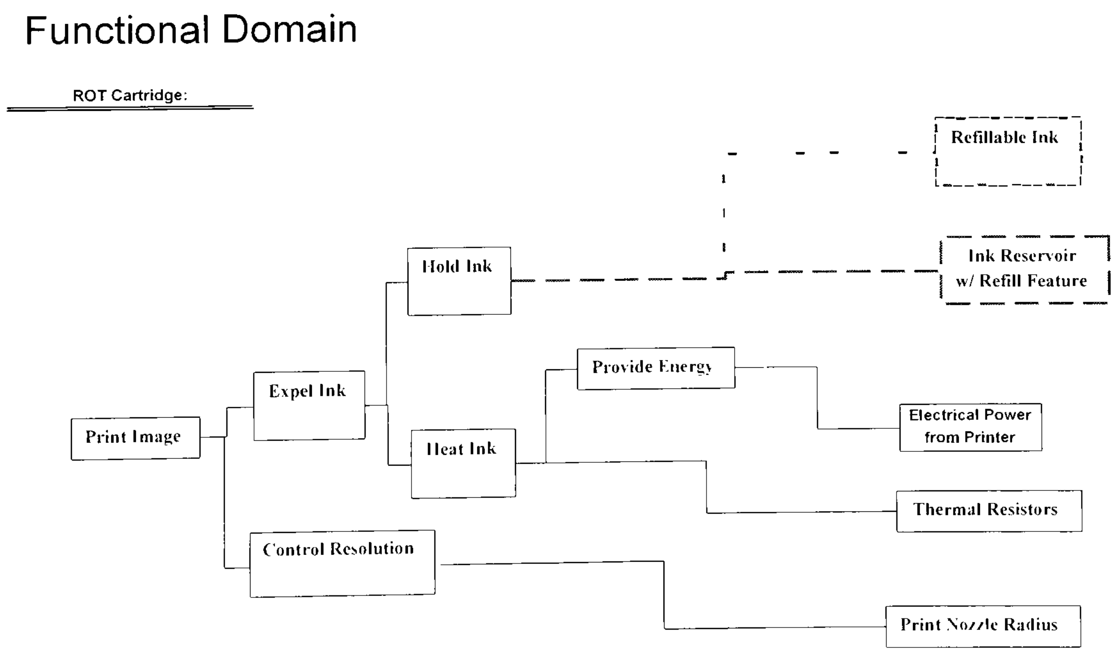


Figure 5.7 – ROT FAST diagram

The functional model (Figure 5.7) of the ROT architecture shows the addition of two components that allow the cartridge to be refillable. The actual ink reservoir is redesigned in order to allow a refilling procedure as described in US Patent # 5408256. Also included in ROT's product offering are ink formulations compliant with HP designs and are specifically designed to reduce wear on the print nozzles.

The components that ROT added to HP's designs are noted in the physical architecture model, Figure 5.8.

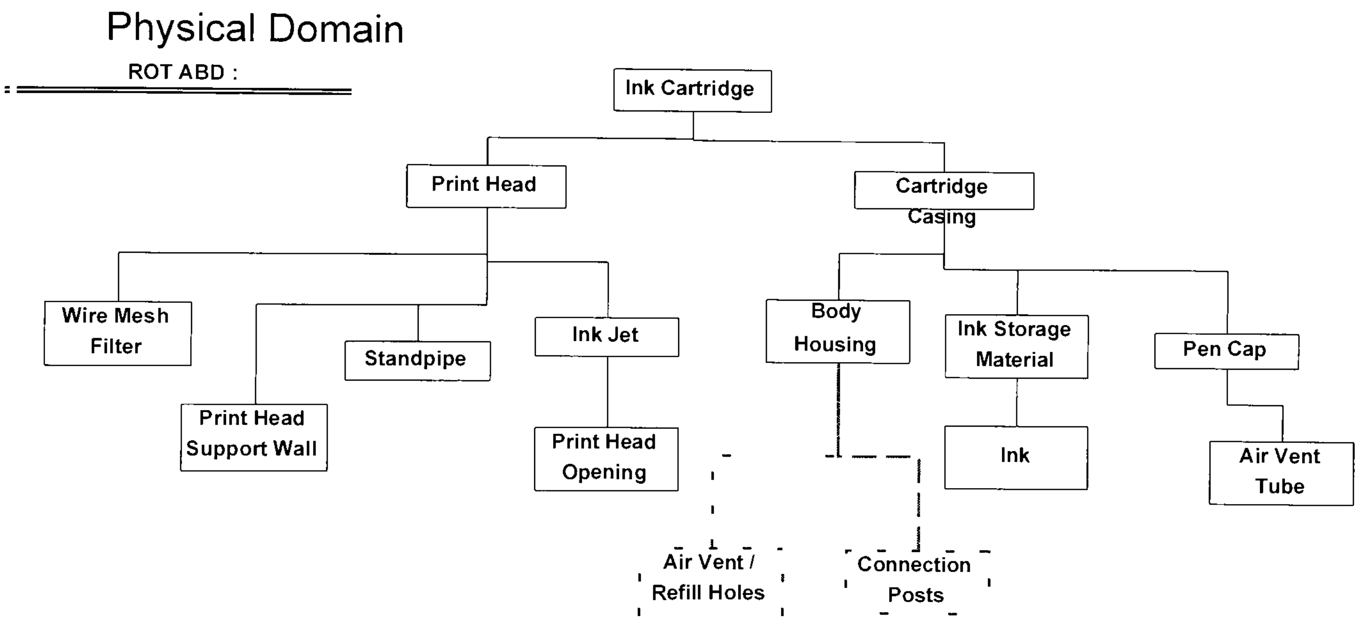


Figure 5.8 – ROT Architectural Block Diagram

The air vents / refill holes were added by ROT to the HP body housing. This feature allows ink to be replaced after a cartridge is exhausted. The Stanley cartridges were also modified by ROT to allow for color refills. They held only a single color, but could be reused in specific HP printers. As a result the ROT cartridge life cycle became substantially more attractive to consumers than HP's model.

Figure 5.9 shows the life cycle of ROT's refillable cartridges. After a cartridge were to run out of ink, the consumer would have the option of throwing it away, or refilling it with ink and installing it in a printer again.

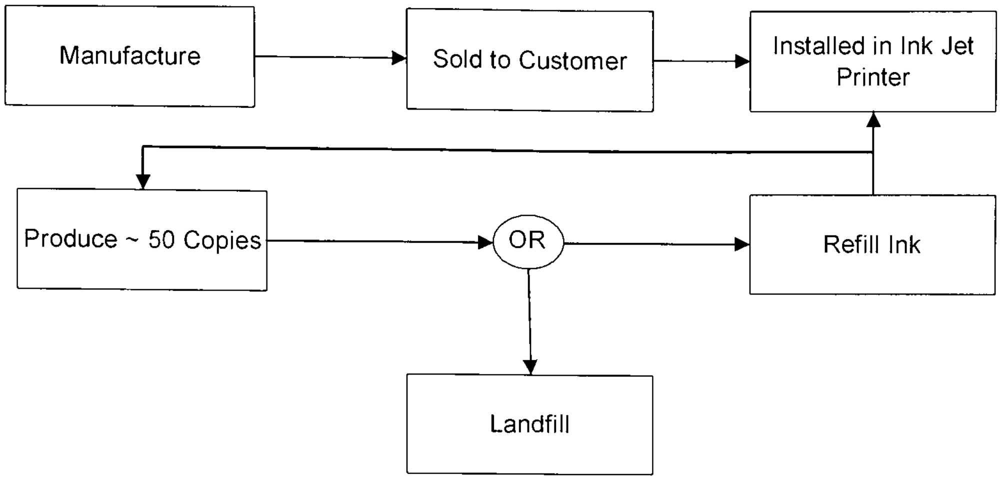


Figure 5.9 – ROT Life cycle diagram

Repeat-O-Type's cartridge adds a refill loop after printing the initial copies which continues until a component of the ink cartridge fails. Failures included decreased printing performance, because of the thermal resistors, and print head clogging.

ROT also added connection posts to the body housing of HP cartridges which enabled the removal and replacement of the pen cap. The process for disassembly and ink replacement is outlined in US Patent # 5408256 as follows:

ROT Refill Process

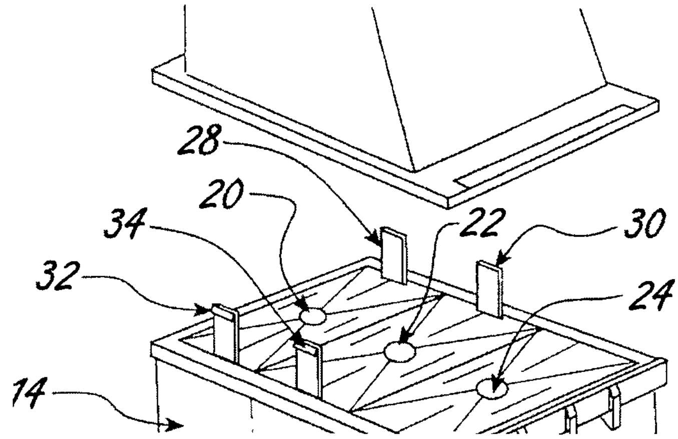


Figure 5.10 – Support posts

The posts added to the body housing can be seen in Figure 5.10 as numbers 32, 34, 28, and 30. The refill holes are 20, 22, and 24. As described earlier, both of these physical components are key enablers for the refill ink function.

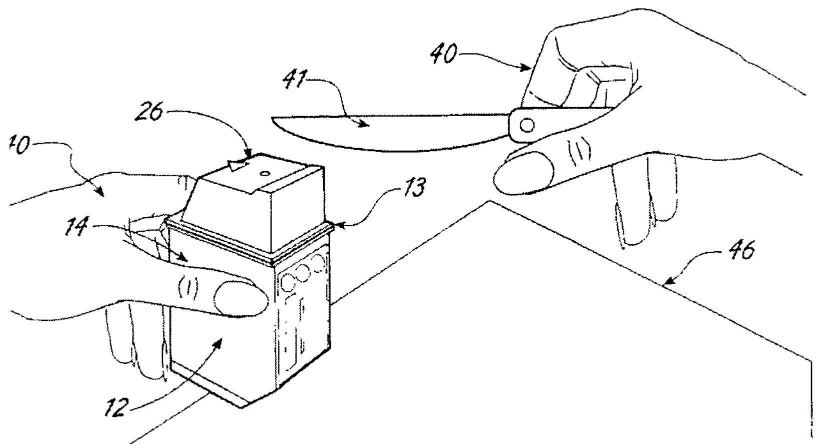


Figure 5.11 – Step 1

Figure 5.11 shows the first step in the ink replacement process. The user (40) separates the pen cap (26) from the body housing (12) using a sharp object such as a knife (41).

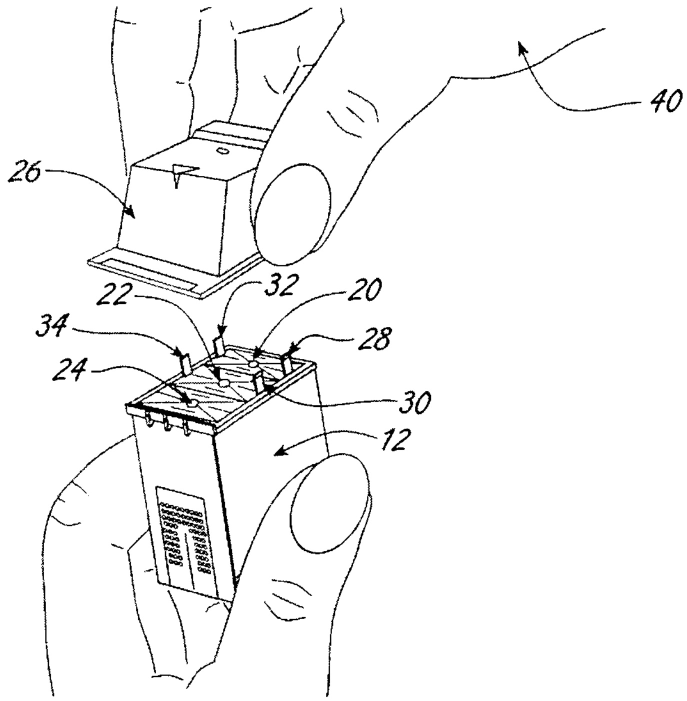


Figure 5.12 – Step 2

Figure 5.12 is a representation of the ink cartridge in its separated orientation. The pen cap (26) is now separate from the body housing (12) and the added body posts (34, 32, 30, 38) as well as the refill holes (24, 22, 20) are now visible.

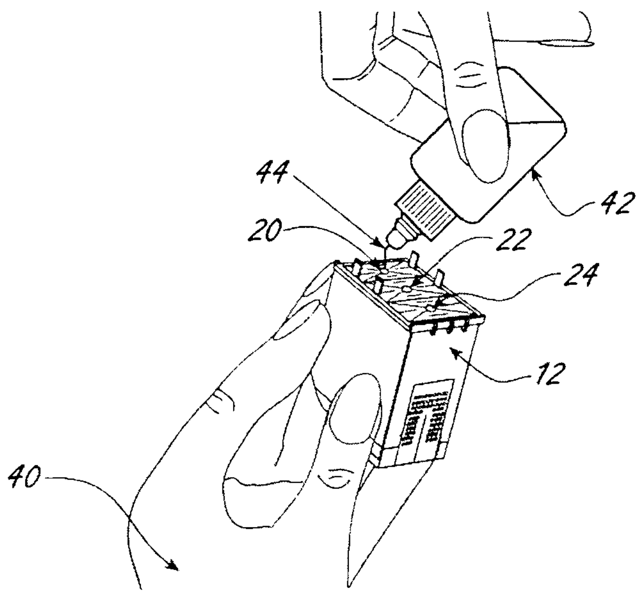


Figure 5.13 – Refill procedure

Figure 5.13 shows the ink refill process. The user (40) holds the body housing (12) in one hand while holding an ink refill bottle (42) in the other. The ink is then added from the refill bottle nozzle (44) into each of the refill holes in the cartridge body (20, 22, 24).

The final step in the process is the reassembly of the ink cartridge body with the pen cap. The product is then ready for reinsertion into the ink jet printer.

Repeat-O-Type patented their process and placed their refill kit alongside new HP cartridges in computer supply stores. The ROT kit came with a refurbished HP cartridge, refill ink, and instructions for replacing ink. Their product provided a better value to consumers than the HP one-use cartridges.

As mentioned earlier, Hewlett Packard soon became aware of Repeat-O-Type's remanufacturing of their products and filed suit claiming infringement on twelve different patents. However the court dismissed each of their claims even after a number of appeals. Repeat-O-Type's legal grounds for the remanufacture of HP products held up in court despite HP's larger size and greater resources.

The next section of this case study will describe the legal strategy that ROT employed.

ROT Legal Strategy

HP originally filed suit against ROT in 1992 after learning that ROT was remanufacturing and selling HP cartridges. The original lawsuit included claims of trademark infringement, unfair competition, as well as the patent infringements. HP dropped the unfair competition claim before the case reached court. Initial court decisions were for HP on the trademark infringement claim and for ROT on all patent infringement claims. HP appealed the patent decisions numerous times. Each appeal was unsuccessful.

The court found ROT to be free from infringement based on a few key points. Repeat-O-Type was buying HP cartridges in bulk and modifying them for resale. According to the law, this initial transaction between HP and ROT was an unconditional sale and afforded the purchaser certain rights to modify the original device. These rights are limited to a certain degree of modification and maintenance. The legal concepts referenced in the case are

"permissible repair" versus "impermissible reconstruction." HP contended that it clearly intended that the cartridges be single use only and, therefore, the ROT modification amounted to impermissible reconstruction. The court's decision however found that modifying a cartridge for refill is simply permissible repair by a user and the patent holder cannot enforce "intended use".

The court's favorable decision for Repeat-O-Type was based on the ruling that ROT purchased HP cartridges unconditionally. They then modified them only as a way to provide maintenance and did not constitute reconstruction of a patented HP product.

Conclusion

The case presented in this chapter provides an example of a follower organization that completed an architectural and intellectual property examination on an existing product and then produced their own product in the same market place. Repeat-O-Type broke down the Hewlett Packard ink jet cartridge product and determined that there was money to be made by producing a product with a longer life cycle. They further examined the intellectual property holdings of HP to find that it was legally possible for them to remanufacture exhausted cartridges and sell them to consumers. Repeat-O-Type's product strategy proved to be correct. Their products were sold in stores alongside HP cartridges and their "refill cartridge" business model is imitated today by a number of firms. In a sense, the follower has become followed.

Defending themselves in court was extremely costly for ROT, especially when compared to the size and resources of Hewlett Packard. Small organizations are often susceptible to 'strong-arm' tactics by larger firms in legal disputes. This is a factor that must be taken into account during the development of the business case. Even a legitimate product can end up putting an organization out of business due to legal problems.

Chapter 6. Case Study

Chunxil Technologies

Introduction

The study presented in this chapter is an examination of a research initiative underway at the Rochester Institute of Technology. The research is being conducted through the Laboratory for Autonomous Cooperative Microsystems (LACOMS) within the Kate Gleason College of Engineering (KGCOE). LACOMS is a multidisciplinary research effort focused on the development and integration of swarm technologies with microsystem technologies.

Swarm research attempts to understand how large numbers of entities with limited intelligence and resources can accomplish sophisticated tasks. For example, social insects construct intricate nests, birds fly in flocks, and fish swim in schools. Microsystem research is focused on developing highly integrated devices that can perform mechanical, electrical, optical, computational and even biological functions using elements that are submillimeter in size.

One research initiative currently underway within LACOMS is the development of swarms of self-guided, self-powered water-bourne microsystems. It is believed that a large number of these sytems working in unison could perform a number of interesting tasks.

The original idea for such a system belongs to Professor Paul Stiebitz of the Industrial and Systems Engineering Department at RIT. His original vision was to develop a series of prototypes over time, each increasing in functionality while decreasing in size (Stiebitz 2001).

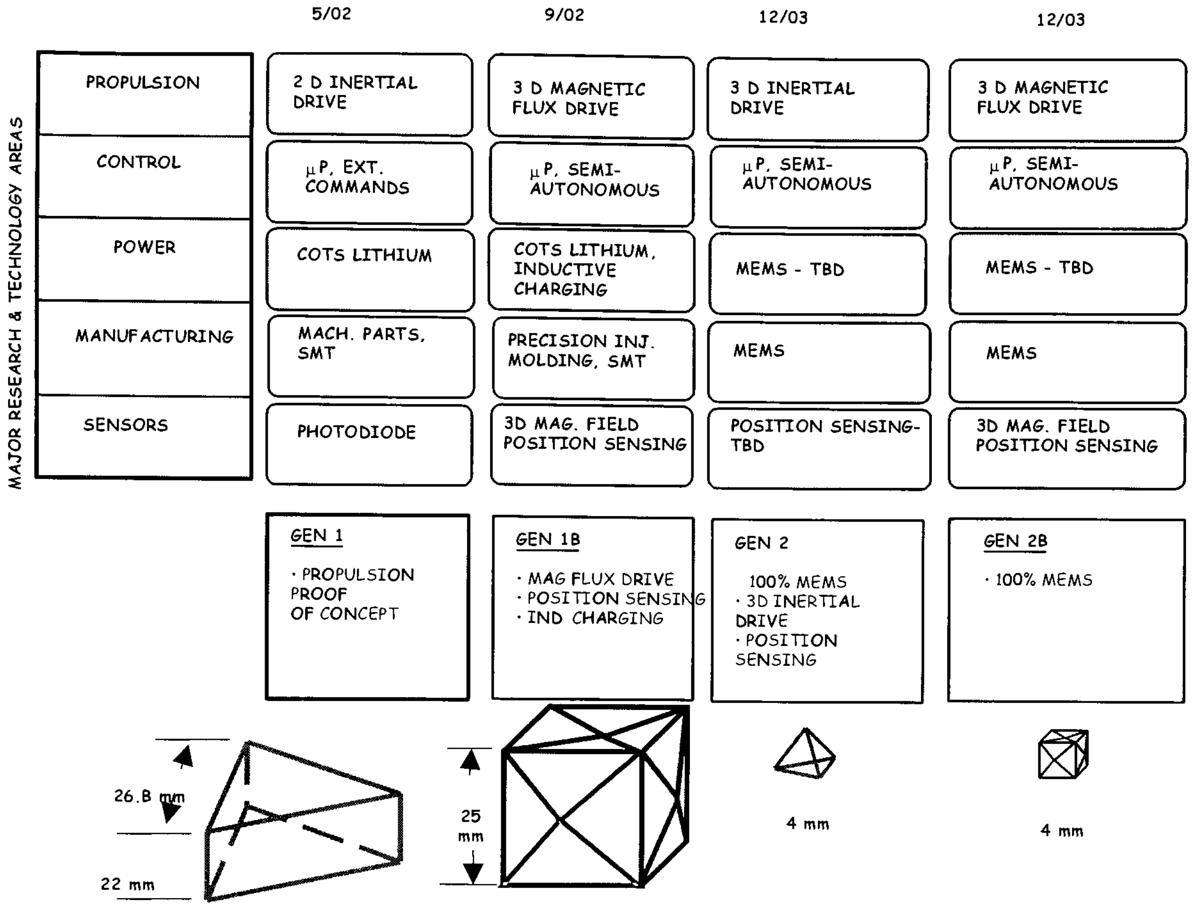


Figure 6.1 – Chunxil timeline (Stiebitz 2001)

Figure 6.1 shows the proposed technology roadmap for the research initiative known as the Proteus Project. The triangular shaped object shown in the diagram was the initial large-scale prototype design. It was the first generation design solution and labeled Proteus after the shape-changing Greek god. Midway through development of the original Proteus, an idea for a second concept lead to the beginning of the Chunxil device shown as the large cube in Figure 6.1. Generation 1B was known as a Chunxil because its intended future use is three-dimensional displays, thus they represent physical pixels or chunks.

At its current stage, the Chunxil prototype shows more functional promise than the Proteus device. For this reason the following case study will primarily discuss the Chunxil. This study will be written from the point of view of an organization seeking to integrate the breakthrough technology intrinsic to Chunxils into commercial products. The study will assume that Chunxils will be patented through the founding organization (RIT) and licensed to fictional company 'Chunxil Technologies' as a leader organization for development.

The Technology of Chunxils

The primary functional goal of the Proteus Project is to produce a large number of devices that collectively can provide controlled autonomous motion in a fluid. The primary breakthroughs that Chunxils represent are in their method of movement and their command and control structure.

Motility

The current generation of Chunxils achieves movement in a fluid using electromagnetic fields. Individual Chunxils contain miniature coils on three perpendicular axes. These coils correspond to six larger coils mounted on the tank in which the Chunxils 'swim'.

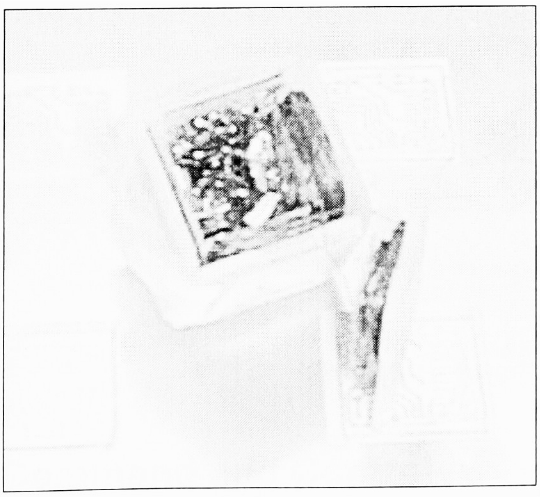


Figure 6.2 – Open Chunxil (Yvanoff)

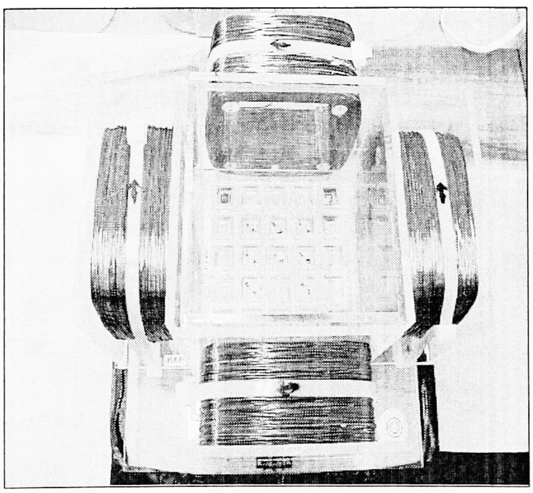


Figure 6.3 – Chunxil tank (Yvanoff)

Figure 6.2 shows a single Chunxil with a wall removed. The three, small, wire bundles are the inner coils. In addition to the three coils, the individual Chunxils contain command and control systems, and power storage.

Figure 6.3 shows the Chunxil tank structure. Coils surround the tank on all six sides (the top coil is removed in the picture). Each coil is designated by a direction, North, South, East, West, Front, and Back. These tank coils are cycled by an external controller in a timed pattern. Each of the six coils is activated for a set period and in a set order during the drive cycle. The individual Chunxils are programmed to activate their coils to coincide with the pattern of the external coils. For example if a Chunxil was required to move towards the West side of the tank to reach its home position, it would wait for the tank cycle to reach the West coil and then activate it's corresponding West coil. This would cause the Chunxil to act as an electromagnet within the magnetic field produced by the West coil. (Figure 6.4).

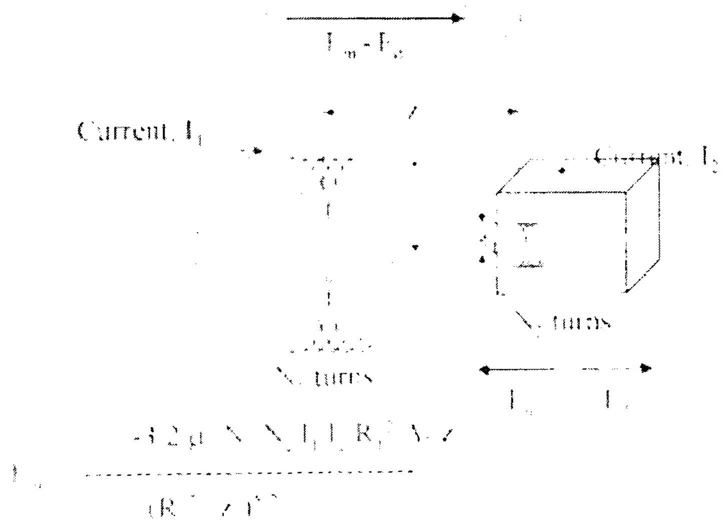


Figure 6.4 – Force on Chunxil – Axial case (Yvanoff)

Command and Control

Chunxils are able to find their home positions through a combination of control algorithms, external commands and environmental stimuli. For this

system the primary environment of the Chunxil is the tank through which it moves. The coils surrounding the tank provide not only a means of locomotion, but a means of communication as well.

Chunxil Technologies

Chunxil Technologies (CT) is a fictitious organization developed for the purposes of this case study. They have negotiated a licensing agreement with the Rochester Institute of Technology that allows them to implement proprietary Chunxil research into commercial products. CT expects to enter the existing field of rapid prototyping, but still consider themselves a leader organization because they feel Chunxils are a breakthrough technology.

Commercial Applications

The primary marketplace that CT aims to enter is rapid prototyping. Rapid prototyping is an emerging tool used by product designers that allows them to quickly and accurately render a three-dimensional design prototype. The basic process of a rapid prototyping system involves taking a part drawing, or other two-dimensional representation of a design, and turning it into a physical, three-dimensional object.

There are currently a number of rapid prototyping technologies available today. These technologies include three-dimensional printing, Shape Deposition Manufacturing, Gelcasting, Microfabrication, and others[3]. Chunxil Technologies hopes to incorporate the research being conducted at RIT into a new form of visual rapid prototyping system.

In order to develop this system, Chunxil Technologies will use the IP / Architecture Process for leader organizations described in Chapter 4. The final product developed by CT will be a package of hardware and software that provides standard interfaces with widely used software design packages and personal computer (PC) hardware, as well as Chunxils and their home environment.

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[3] http://www.rpmi.marc.gatech.edu/

IP / Architecture Process

In order for CT to create a lasting, profitable and protected product, IP requirements must be a concern from the very first step. The following process is a micro-view of the overall architecting process with an emphasis on the intellectual property aspects for Chunxil Technology's product. Many other concerns must be considered at each step, but for this case study, the IP integration will be the main topic of examination.

Scoping

The first stage of product architecture is the scoping phase. During this phase, architects must be sure to identify all necessary requirements for the product being designed. These requirements include function, cost, health and safety, and many others. The most important requirements for this case are the intellectual property requirements. The following excerpt from Chunxil Technologies requirements document describes the IP essentials for the product:

1.0 Intellectual Property Requirements
- 1.1 The finished product shall adhere to all claims and regulations from the RIT licensing agreement
- 1.2 Software Development
  - 1.2.1 The integration software should be compatible with popular design packages such as I-deas™, AutoCAD™, and ProE™ "out of the box".
  - 1.2.2 Software shall be written in such a way as for customers to be able to integrate their own design software if necessary.
  - 1.2.3 The backend of the translation software shall be proprietary.
- 1.3 The finished product should be partitioned in such a way as to keep components with similar IP restrictions together and separate from those with alternate IP restrictions.

These IP requirements represent a subset of the overall design requirements that would be completed during the scoping phase of the architecture development.

Modeling

The purpose of the modeling phase in the Chunxil development process is to provide representations of how the design requirements from the scoping phase will be met. The IP requirements from the scoping phase can best be translated into models that describe the need for interaction between the Chunxil system and outside design software, and the partitioning of like protected components.

Chunxil System AFD

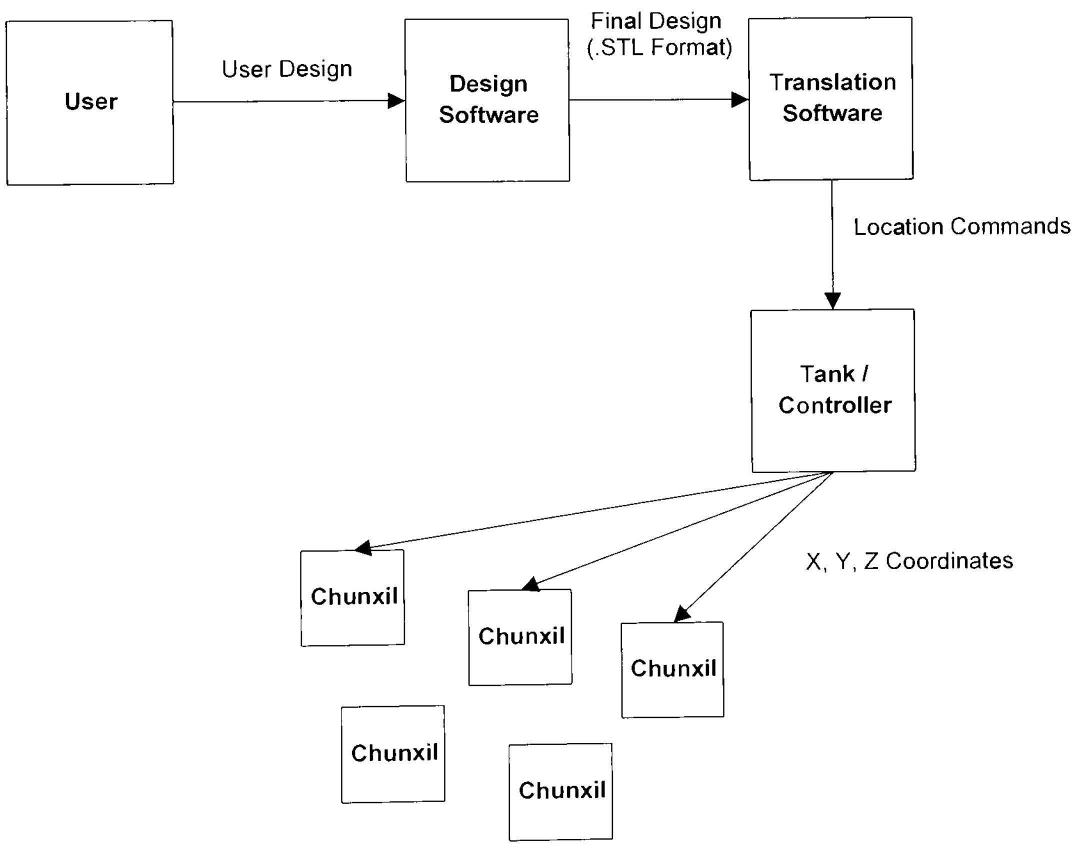

Figure 6.7 – Chunxil system architectural flow diagram

The architectural flow diagram in Figure 6.7 shows the top-level flow of information within the Chunxil Technologies system. The user inputs his or her design into software on a PC. This design is then translated from the format used by the design software into a format the Chunxil Technologies' controller can understand. The tank controller utilizes the large coils surrounding the tank to transmit X, Y, and Z coordinates to each Chunxil that will be used in the prototype.

Within this flow of information, it is imperative that Chunxil Technologies take steps to protect their value-added processes. The translation software depicted in the AFD performs an integral function. According to the requirements, it must be able to interface with common design software as well as be programmed to accept commands from custom design software. This software should be copyrighted, as is most software, but more importantly, the input parameters should be publicly available while the core code kept a trade secret. For example, the software can be modeled such as in Figure 6.8:

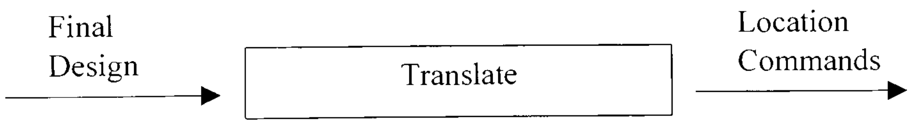

Figure 6.8 – Software functionality

The inputs acceptable for final design should be documented public knowledge, however, the code that performs the translation function should be proprietary as well as the values for location commands.

Design choices made in accordance with these diagrams would satisfy the IP requirements noted as "1.2 Software Development" in the scoping phase.

Partitioning / Aggregation

The partitioning and aggregation phases of the Chunxil Technology product architecture development process must adhere to the requirement that states:

1.3 The finished product should be partitioned in such a way as to keep components with similar IP restrictions together and separate from those with alternate IP restrictions.

This requirement can best be communicated by the system architects to the product development team through the use of an architectural block diagram. The following ABD illustrates a partitioning and aggregation method for a device in which IP strategy is paramount.

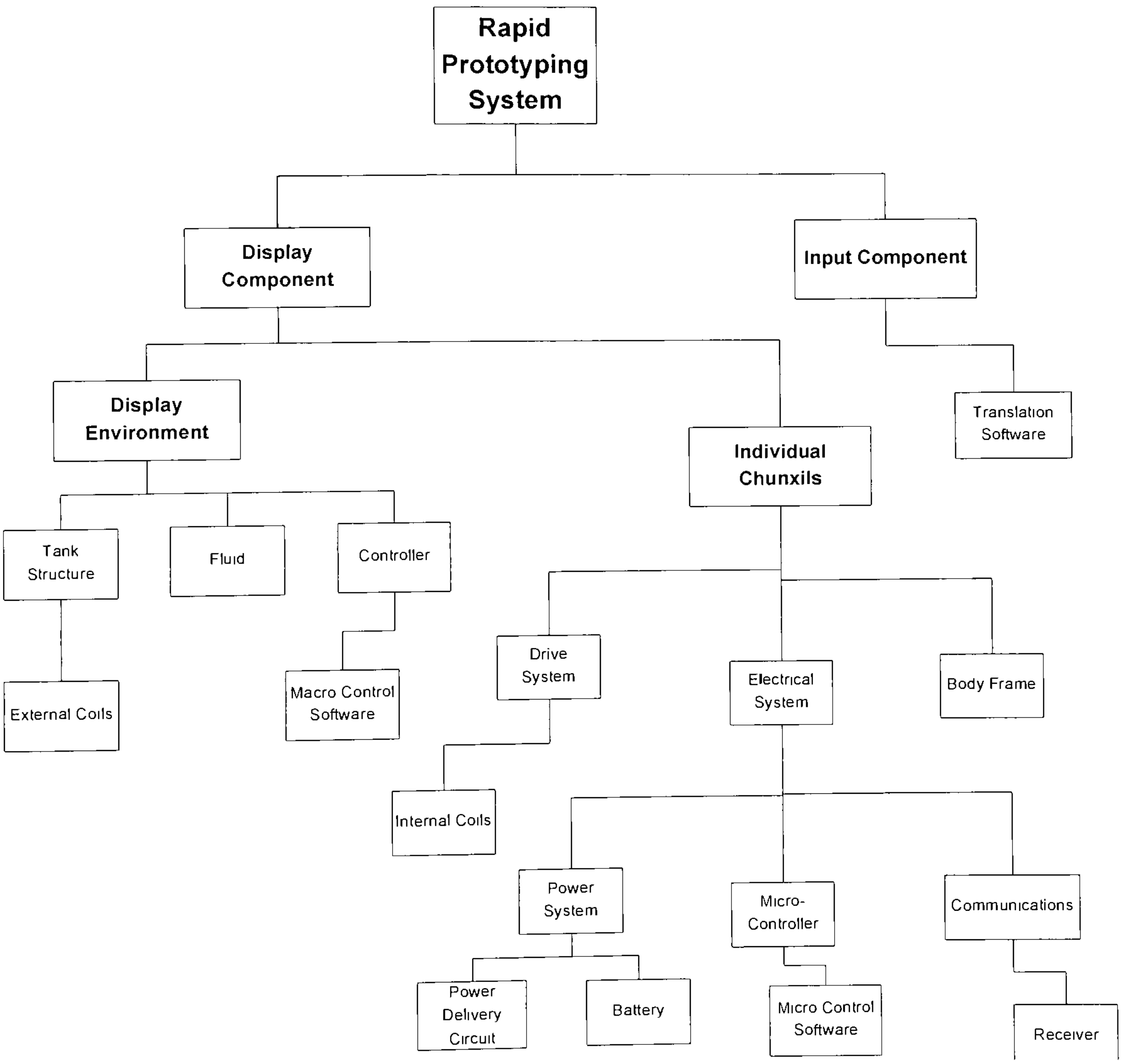

Figure 6.9 – Chunxil system architectural block diagram

The Chunxil display system ABD (Figure 6.9) shows the breakdown of each major component of the overall product. In accordance with requirement 1.3 from the scoping phase, it is recommended that the components with similar IP protections be coupled. This coupling occurs in various places outlined by the ABD. One major area of the design that is likely to have similar protection schemes is the software components, represented in the diagram as translation software, macro control software and micro control software. These three types of software are shown as separated physical entities on the diagram, but in actual use, commands will flow directly from translation to macro to micro as is depicted in Figure 6.7. These three components of the final product will then be virtually coupled by function.

The rest of the design is highly modularized. This modularity lends itself to a strong intellectual property protection strategy. Each of the main components, the display component, and the individual Chunxil components, can be protected under separate utility patents. The ABD also shows a further division within the Chunxil design. The diagram implies separate individual systems for power, communications, and command features. This modularity will further strengthen the design from an IP standpoint.

Integration

The next step in the Chunxil Technologies architecture development process is integration. The integration of an architecture occurs when the designer chooses how the different chunks, developed in the last step, will communicate with each other.

The primary channels of communication related to the rapid prototyping device are from the design software to the macro control module facilitated by the translation software, and then from the macro control device to each micro control device onboard the individual Chunxils.

The requirements developed in the scoping phase stated that the translation software should be compatible with a wide variety of design software. This means that the translation software should be open to developers and well documented.

There is currently an open format for rapid prototyping design software known as the .STL file format.

> An StL ("StereoLithography") file is a triangular representation of a 3-dimensional surface geometry. The surface is tessellated or broken down logically into a series of small triangles (facets). Each facet is described by a perpendicular direction and three points representing the vertices (corners) of the triangle. These data are used by a slicing algorithm to determine the cross sections of the 3-dimensional shape to be built by the fabber. (Burns 152)

Compliance of the translation software with this existing open format will ensure that the rapid prototyping product will work with existing design software.

The internal communications from the macro controller to the micro controller should be just the opposite. A closed system of communication, either through encryption or non-standard parts, will make it more difficult for competitors to reproduce the product on a piece by piece basis. The goal for the internal design of the Chunxil system should be modular components with protected interfaces, as depicted in Figure 6.10.

Chunxil Interfaces

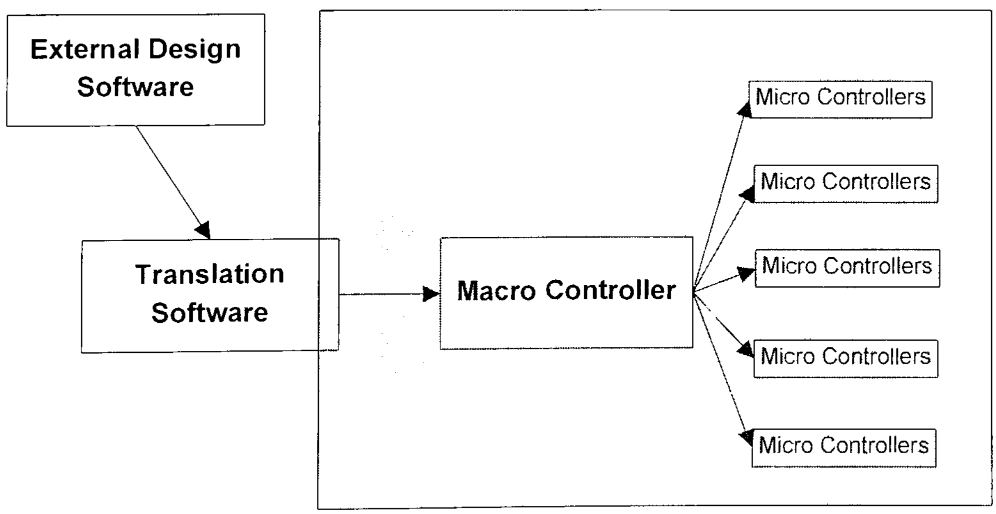

Figure 6.10 – Chunxil interfaces

The gray shaded box represents a proprietary communication scheme. This figure implies that the interaction between the external design software and

the translation software should be publicly available and documented. Also the functions performed by the translation software should be documented up to what is sent to the macro controller. The rest of the communications between system components should be protected. The inside of the gray box constitutes a closed system, while the outside would be developed as an open system.

Assessing

Assessment of the IP / Architecture strategy illustrated in this case study would occur during further development and commercialization of the product. The current architecture is the most appropriate for current design criteria and requirements. If these were to change due to competitor influences, changing customer preference, or any other factor, an architecture assessment may lead to a different design. Therefore, the assessment phase of the architecture development should be an ongoing task throughout the life of the product.

Conclusion

The hypothetical case study presented in this section outlined an example of the fictitious firm, Chunxil Technologies, and their commercialization of an actual research and development project underway at RIT. The goal of this case study was to provide an example of how the IP-Architecture process created in this thesis would work for a leader organization. A top-level architecture for a rapid prototyping system was defined using this process. This architecture would lead to a successful commercial development. However, the effectiveness of the design could only be determined after it is introduced to the market.

Chapter 7. Conclusion

The pursuit of profit drives organizations to supply products that customers want. In order to do this, firms take an idea from concept to commercial offering through various types of product development processes. One of the main goals of this thesis was to stress the importance of intellectual property during the architecting phase of any product development process.

The objective of this thesis is to provide product architects a process and decision tool for incorporating their organization's intellectual property strategies into new products.

The original problem was stated as research questions involving two types of firms. Leader firms, which attempt to commercialize new or breakthrough technologies, and follower firms, which enter already established markets by copying or improving on already existing products. Research questions were developed for each:

Market Leaders:

1. How do leader firms integrate new technologies into well-protected and hard to duplicate products?

Market Followers:

2. Given that a market is worth entering, how do follower firms develop the best-suited product for entry?

To answer the research questions, a background literature review was conducted in Chapter 2, followed by a deeper description of product architecture in Chapter 3. Chapter 4 includes the process developed in response to the research questions. Chapter 5 is a case study of follower organization Repeat-O-Type and their infiltration of the ink jet printing consumables market. Chapter 6 is a case study written from the point of view of a fictitious leader organization and the optimal product architecture for their commercial product. Both cases illustrate the IP / Architecture process outlined in Chapter 4.

Further Research

The process described in this thesis is very high level. Its uses may vary in different industries and for different types of products. There is ample opportunity for further research involving many other case studies and examples. The progression of this work would involve applications to particular industries, the development of design and architecting heuristics, further and more complex decision models, and ultimately a point-and-click software tool to be used by product architects.

One area in particular in which this process could be adjusted and applied is software development. A number of Glazier's twelve rules apply specifically to software. Also, the fact that most software is copyrighted as opposed to protected by patents would lead to different architecture requirements.

Bibliography

Systems Architecture Sources

Arnold, Stuart and Peter Brook, Ken Jackson, Richard Stevens. Systems Engineering: Coping with Complexity. Europe: Prentice Hall, 1998.

Beam, Walter R. Systems Engineering: Architecture and Design. McGraw Hill, 1990.

Christensen, Clayton M. Innovation and the General Manager. McGraw-Hill, 1999.

Lynch, Charles L. and Andrew P. Sage. "Systems Integration and Architecting: An Overview of Principles, Practices, and Perspectives", The Journal of The International Council on Systems Engineering Volume 1, Issue 3, 1998.

Maier, Mark W. and Eberhardt Rechtin. The Art of Systems Architecting. Boca Raton: CRC Press, 1997.

Rectin, E. Systems Architecting: Creating and Building Complex Systems. Englewood Cliffs, NJ: Prentice-Hall. 1991.

Stiebitz, Paul. Engineering of Systems I Lectures. Building 78, Rochester Institute of Technology. Fall 2002.

Ulrich, Karl T. and Eppinger, Steven D. Product Design and Development. McGraw-Hill 1995.

Intellectual Property Sources

Applegate, Lynda M. and Gavin Clarkson. "Intellectual Asset Valuation." HBS Case No. 9-801-192. Boston: Harvard Business School Publishing, 2000.

Glazier, Stephen C. Patents Strategies for Business. Maryland: Law & Business Institute, 2000.

Hart, Myra. "Palm Computing, Inc. (A)." HBS Case No. 9-396-245 Boston: Harvard Business School Publishing, 1996.

Kline, David and Kevin G. Rivette. "Discovering New Value in Intellectual Property", *Harvard Business Review* January-February 2000. pp 1-12.

-----. Unlocking the Hidden Value of Patents: Rembrandts in the Attic. Boston: Harvard Business School Publishing, 2000.

Tripsas, Mary. "Adobe Systems, Inc." HBS Case No: 9-801-199/Rev. 12/13/01. Boston: Harvard Business School Publishing, 2000.

Other Sources

Burns, Marshall. Automated Fabrication Improving Productivity in Manufacturing. Prentice Hall, July 1993.

Stiebitz, Paul. Inertial Drives for Water-borne Autonomous Microrobots. Unpublished paper. Rochester Institute of Technology. Nov 30, 2001.

The American Heritage® Dictionary of the English Language, Fourth Edition. 2000 Houghton Mifflin Company.

Yvanoff, Marie. Autonomous Underwater Vehicle Proteus- Generation 1b. Unpublished paper. Rochester Institute of Technology. Aug 2002.

Appendix A. ROT vs. HP Legal Summary

UNITED STATES COURT OF APPEALS FOR THE FEDERAL CIRCUIT

96-1379

HEWLETT-PACKARD COMPANY,

Plaintiff-Appellant,

v.

REPEAT-O-TYPE STENCIL MANUFACTURING CORPORATION, INC. and
FRED KEEN,

Defendants-Appellees.

S. Leslie Misrock, Pennie & Edmonds, of New York, New York, argued for plaintiff-appellant. With him on the brief were Jonathan A Marshall, William G. Pecau, Steven I. Wallach, Alan Tenenbaum, and Neer Gupta. Of counsel on the brief were Morgan Chu and Bruce D. Kuyper, Irell & Manella LLP, of Los Angeles, California, and William H. MacAllister and Edward Maker II, Hewlett-Packard Company, of Palo Alto, California.

Edward F. O'Connor, Poms, Smith, Lande & Rose, of Irvine, California, argued for defendants-appellees.

Appealed from: U.S. District Court for the Northern District of California
Judge Jensen

United States Court of Appeals for the Federal Circuit

96-1379

HEWLETT-PACKARD COMPANY,

Plaintiff-Appellant,

v.

REPEAT-O-TYPE STENCIL MANUFACTURING CORPORATION, INC. and FRED KEEN,

Defendant- Appellees.

DECIDED: August 12, 1997

Before ARCHER, Chief Judge, MAYER, and LOURIE, Circuit Judges.
LOURIE, Circuit Judge.

Hewlett-Packard Company (HP) appeals from the summary judgment of the United States District Court for the Northern District of California, holding that Repeat-O-Type (ROT) does not infringe any of the asserted patents by modifying and reselling HP's ink jet cartridges. Hewlett-Packard Co. v. Repeat-O-Type, Inc., No. 92-CV-3330 (N.D. Cal. Apr. 17, 1996). Because ROT's modification does not constitute impermissible reconstruction and because HP has failed to raise genuine issues of material fact regarding infringement of any of the patents in suit, we affirm.

BACKGROUND

HP manufactures and sells ink jet printers and disposable ink jet cartridges for its printers. Before running out of ink, the cartridges can print approximately 200 to 2000 pages, depending on the cartridge used and the nature of the printing being performed. Once the ink in a cartridge has been depleted, HP expects the cartridge to be discarded and replaced by a new one. Instructions accompanying the cartridges disclaim liability for printer damage caused by refilling and advise the user to "discard old print cartridge immediately."

The HP cartridges use thermal ink jet printing technology in which ink is transferred, drop-by-drop, onto paper, overhead transparencies, or other similar media. Specifically, the cartridges employ a printhead containing thermal resistors that are fabricated within a thin-film-semiconductor substrate and heat and propel ("jet") tiny droplets of liquid ink onto a medium, such as paper. The cartridges also contain an ink reservoir that stores the ink transferred to the printhead during printing. During the ink jet printing process, the printer's electronics provide electrical energy to the cartridge, which conducts the energy through the thermal resistors in the printhead, causing the thermal resistors to heat. As a result, the ink which is delivered to the resistors boils and forms a vapor, which causes nearby ink droplets to be propelled out of the cartridge and onto the paper or other medium. HP warns its customers that refilling the cartridges may reduce print quality due to clogging of the printhead nozzles, corrosion of the cartridge electronics, or incompatibility of non-approved inks with the cartridges.

HP owns numerous patents on various facets of ink jet printing technology, including patents on ink jet printers, cartridges, and ink formulations. Twelve of these patents are involved in this suit. Of the twelve asserted patents, two of them, U.S. Patents 4,827,294 and 4,931,811, are directed to ink jet cartridges (referred to in the patents as "ink jet pens") and a third, U.S. Patent 5,108,503, is directed to a specific ink formulation. The remaining patents are directed to other aspects of ink jet printing technology and are directed to specific components within ink jet cartridges: U.S.

Patents 4,347,524 (shock absorption of an ink supply tube); 4,635,073 (thermal printhead); 4,683,481 (thermal resistors in substrate); 4,771,295 (process for filling an ink jet cartridge with ink); 4,794,410 (thermal resistor structure); 4,794,411 (ink propulsion from printhead); 4,812,859 (multichamber ink jet pen); 4,862,197 (thin-film-resistor printhead); and 4,872,027 (printer and ink jet printhead and their interconnection).

The '294 patent, entitled "Thermal Ink Jet Printhead Assembly Employing Beam Lead Interconnect Circuit," is directed to an "ink jet pen" (i.e., a cartridge), which forms an improved electrical connection between the printhead of the pen and the ink jet printer carriage in which the pen is mounted.

Claim 3 of the '294 patent, which is representative, reads as follows:

> An ink jet pen including in combination:
>
> (a) a pen body housing having an ink storage compartment therein and an ink flow port adjacent one surface thereof and further having outer surfaces which are contoured to mate with adjacent surfaces of a pen carriage member,
>
> (b) a thin film printhead mounted on said one surface of said pen body housing and adjacent to said ink flow port therein for receiving ink from said ink flow port during an ink jet printing operation, and
>
> (c) a flexible electrical circuit member including a plurality of beam leads bonded at predetermined locations on said thin film printhead for supplying electrical power and signals thereto during an ink jet printing operation, said flexible electrical circuit being extended over one of said contoured outer surfaces of said pen body housing and secured thereto, whereby electrical conductors in a pen carriage are adapted to mate with certain ones of said beam leads of said flexible electrical circuit for supplying power and electrical drive signals to said beam leads when said pen body housing is mounted in said carriage.

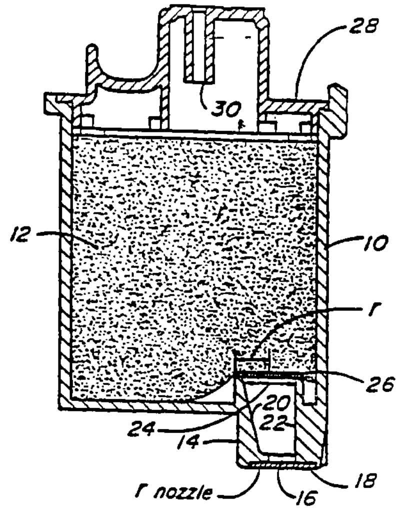

Fig. 1

The '811 patent, entitled "Thermal Ink Jet Pen Having A Feedtube With Improved Sizing And Operational With A Minimum Of Depriming," is directed to an "ink jet pen" that uses a "standpipe" to improve the connection between the ink reservoir and the printhead.

As illustrated in the accompanying diagram from the '811 patent, the pen body construction includes a pen body housing (10) and a cap (28). The pen body also includes a foam storage material (12) which serves as the ink reservoir, a standpipe formed by walls (20) and (22), and a printhead (18). The cap (28) has an air vent tube (30) for supplying air to the ink reservoir as ink is transferred through the standpipe to the printhead. The patented invention improves on the prior art by providing a standpipe that prevents air bubbles from impeding the flow of ink to the printhead.
Claim 2 of the '811 patent, which is representative, reads as follows:

> 2. A thermal ink jet pen including an ink reservoir therein, and a thin film printhead interconnected to said reservoir by way of a standpipe, with said standpipe having an air accumulating section at the ink receiving end thereof and said thin film printhead including an orifice plate with a plurality of orifii therein of a known radius, rnozzle characterized in that the minimum acceptable radius, r, of said air accumulating section of said standpipe satisfies the equation r/rnozzle > 100.

The '503 patent, entitled "Smear Resistant Inks For Ink jet Printers," is directed to an ink formulation. Claim 2 depends from claim 1, which has recently been disclaimed, and adds the following limitation: "The ink of claim 1 which is buffered to a pH from about 6 to about 9." Likewise, claims 15 and 19 are limited to formulations containing "sufficient ammonium acetate . . . to provide an ink with a pH from about 7 to about 7.5 . . . ." The other asserted claims, 3, 8, 10, 16, and 18, depend from either claims 2 and 15 and thus incorporate the pH limitations.

ROT purchases two types of HP ink jet cartridges, model HP 51625A (known within HP as the "Kukla" cartridge) and model HP 51608A (known within HP as the "Stanley" cartridge). The Kukla cartridge is designed for color printing and contains three reservoirs which hold inks corresponding to the three primary subtractive colors. The Kukla cartridge includes a cap that is ultrasonically welded to the rest of the body of the cartridge, the cap being designed to permit small amounts of air to enter the ink reservoir. The Stanley cartridge, on the other hand, has a single reservoir and is sold by HP with black ink only. It is designed for use with the DeskJet and DeskWriter family of ink jet printers and for the HP FAX-300 ink jet fax machine. The Stanley cartridge includes a hole that is used to fill the ink reservoir at the time of manufacture and also allows air to enter the reservoir during printing.

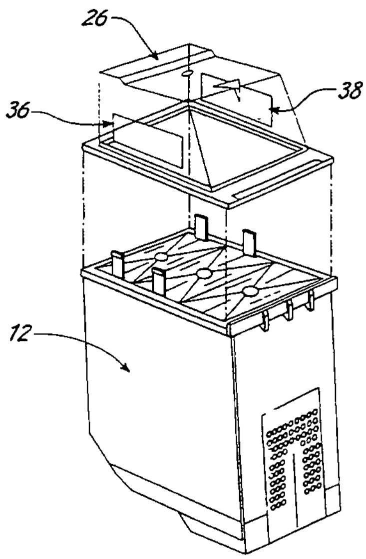

FIGURE 3

The Kukla and Stanley cartridges were designed to be non-refillable. As James M. Martin, a product manager for HP, stated, because "refilled cartridges present significant problems of resistor lifetime, nozzle clogging and air bubble formation, the cartridges are not intended to be refilled. Accordingly, the user instructions in the Kukla and Stanley cartridges advise the user to 'Discard old print cartridge immediately.'" ROT has chosen to disregard HP's advice. ROT purchases Kukla and Stanley cartridges, modifies them so that they will be refillable, and then resells them as refillable ink jet cartridges. As HP concedes, ROT starts with brand-new and unused HP cartridges. It does not modify "spent" cartridges. ROT clearly describes the cartridge modification in its own patent, U.S. Patent 5,408,256, entitled "Refillable Color Ink Jet Cartridge And Method For Making Said Cartridge:"

> A non-refillable color ink jet cartridge such as the Hewlett-Packard #51625A can be converted into a refillable cartridge. The upper portion of this cartridge contains the three air vent/ink refill holes, and this upper portion has a plastic cap capable of being removed. After placing the body of the plastic cartridge on a suitable support such as, for example, the edge of a table, the protective plastic cap covering the upper portion of the cartridge can be removed by prying it off of a cartridge with a sharp instrument such as a knife.
>
> The upper protective cap [26] can now be modified so that it can be placed snugly back onto the main cartridge body [12] as often as is necessary to replenish depleted ink supplies. A variety of methods can be employed to do this, including placing two adhesive backed pads [36 and 38] at both sides of the longitudinal length of the upper protective cap.

'256 Patent, col. 1, line 56 to col.2, line 18. ROT sells the modified refillable ink jet cartridges in kits which also contain bottles of refillable ink. The refillable ink is not manufactured or supplied by HP. In addition to modifying the cartridges, ROT replaces the black ink of Stanley cartridges with a variety of color inks and resells them as color cartridges.

In 1992, HP filed suit against ROT after learning that ROT was selling refillable ink jet cartridges. In its original complaint, HP sued ROT for trademark infringement, unfair competition, and other non-patent causes of action. Shortly thereafter, HP amended its complaint to assert that ROT's modification and resale of the cartridges infringed eleven HP patents

pertaining to ink jet cartridges. HP also amended the complaint to assert that the inks sold by ROT infringed one of HP's ink patents and to add Fred Keen, ROT's president and majority stockholder, as a defendant.

ROT moved for summary judgment of non-infringement of all of the asserted patents, and HP moved for summary judgment of infringement on the trademark claims and on two of the patent claims. HP asserted that ROT's resale of the modified Stanley cartridge infringed the '811 patent and that ROT's resale of the modified Kukla cartridge infringed the '294 patent. After hearing arguments on the cross-motions for summary judgment, the district court ruled in favor of HP on the trademark infringement claims and in favor of ROT on the patent infringement claims. The trademark ruling was not appealed.

With regard to patent infringement, the district court first stated that, in light of HP's sale, ROT had the right to use and resell Kukla and Stanley cartridges that were lawfully purchased. The court then considered whether ROT's modification created an infringing product. The court noted that ink was not an element of the claimed invention of the '811 patent. Thus, the court held that ROT's replacement of the ink, a non-patented component, in the Stanley cartridge was not patent infringement.

As for the '294 patent, the court noted that the cap is not an element of the claims and held that "breaking the seal of the cap and replacing the cap with shims so that the cap could be removed and the cartridge refilled by the consumer, does not constitute impermissible 'reconstruction.'" Finally, holding that HP failed to present sufficient evidence of infringement to create any genuine issues of material fact, the court ruled that ROT was entitled to judgment of non-infringement on all the patent claims as a matter of law. Finding no just reason for delay, the district court entered final judgment on the patent claims pursuant to Fed. R. Civ. P. 54(b). HP now appeals to this court. We have jurisdiction to hear this appeal under 28 U.S.C. § 1295(a)(1) (1994).

DISCUSSION

We review a district court's grant of summary judgment de novo. Conroy v. Reebok Int'l, Ltd., 14 F.3d 1570, 1575, 29 USPQ2d 1373, 1377 (Fed. Cir.

1994). Summary judgment is appropriate when no genuine issue exists as to any material fact and the moving party is entitled to judgment as a matter of law. Fed. R. Civ. P. 56(c). Thus, summary judgment may be granted when no "reasonable jury could return a verdict for the nonmoving party." Anderson v. Liberty Lobby, Inc., 477 U.S. 242, 248 (1986). In determining whether there is a genuine issue of material fact, the evidence must be viewed in the light most favorable to the party opposing the motion, with doubts resolved in favor of the opponent. Transmatic, Inc. v. Gulton Indus., Inc., 53 F.3d 1270, 1274, 35 USPQ2d 1035, 1038 (Fed. Cir. 1995).

A. The '294 and '811 Patents

The patent statute provides that "whoever without authority makes, uses, . . . or sells any patented invention, in the United States . . . during the term of the patent therefor, infringes the patent." 35 U.S.C. § 271(a) (1994). Infringement thus not only requires that claims read on accused devices, but also requires that the accused devices be made, used, or sold without authority. Thus, even if the patents in suit read on the accused cartridges, there is no infringement if ROT acted "with authority" granted by HP's unconditional sale of the cartridges in question.

HP argues that ROT's modification and resale of the Stanley and Kukla cartridges infringes the '294 and '811 patents. HP first asserts that the district court erred in its interpretation of the claims of the '294 and '811 patents and that this error infected the district court's infringement analysis. Specifically, HP argues that the district court erred by holding that the "patents are not for the [ink jet] cartridges themselves; they are for certain elements which are in the cartridges" (emphasis in original).

HP also argues that ROT's modification creates new cartridges because the modified cartridges have different properties, different features, and different performance characteristics compared with the cartridges sold by HP. HP contends that because ROT sells cartridges that differ from the cartridges purchased from HP, the cartridges are "new," not "authorized," and therefore infringe. HP emphasizes that, although the cap is not explicitly recited in the claims, the cap on the Kukla cartridge is part of the "pen body housing" recited in claim 3 of the '294 patent. Thus, HP argues, modification of the cap necessarily involves modification of the claimed "pen body housing" and thus the use and sale after such modification is an infringement. Similarly, HP argues that the cap of the Stanley cartridge is part of the claimed "ink reservoir" of claim 2 of the '811 patent.

ROT responds that refilling the ink in the cartridges cannot constitute infringement, because, while HP may have a patent on the cartridge, i.e., the container, HP does not have a patent on the contents of the container, specifically, the ink. ROT further argues that the replacement of components of the cartridges that are not specifically recited elements of the asserted claims cannot be considered a "manufacture" of the claimed inventions. ROT argues that because neither the cap nor the ink are recited elements of the claims, their modification or replacement cannot constitute infringement.

We agree with HP that the court misconstrued the claims. They relate to ink jet cartridges, not to specific components within the cartridges. The preamble of each claim clearly states that it relates to an "ink jet pen including" the recited limitations. The claim term "including" is synonymous with "comprising," thereby permitting the inclusion of unnamed components. Thus, claim 3 of the '294 patent, for example, reads on ink jet pens that contain the recited pen body housing, thin film printhead, and the flexible electrical circuit member. If these three elements can be identified in ROT's cartridges, then such cartridges are within the scope of that claim and the unauthorized manufacture or sale of such a cartridge infringes the claim.

Although the district court did not construe the claim terms "pen body housing" or "ink reservoir," and hence did not consider whether modification of the cap results in a modification of specific elements of the claims, for purposes of our inquiry into ROT's "authority," we will assume that HP's patents read on ROT's modified cartridges. We will also assume that modification of the cap involves "making" the "ink jet pens" claimed in the '294 and '811 patents. The question before us is whether this modification is authorized, or whether it exceeds the scope of the implied license granted to ROT and subsequent purchasers by the sale of the ink jet cartridges.

Generally, when a seller sells a product without restriction, it in effect promises the purchaser that in exchange for the price paid, it will not interfere with the purchaser's full enjoyment of the product purchased. The buyer has an implied license under any patents of the seller that dominate the product or any uses of the product to which the parties might reasonably contemplate the product will be put. See Mitchell v. Hawley, 83 U.S. (16 Wall.) 544, 548 (1872) ("Complete title to the implement or machine

purchased becomes vested in the vendee by the sale and purchase . . . . Patented implements or machines sold to be used in the ordinary pursuits of life become the private individual property of the purchasers, and are no longer specifically protected by the patent laws . . . .").

The authority to use and sell a purchased device, however, does not include the right to make a new device or to reconstruct one which has been spent. Reconstruction, i.e., the re-creation of a patented combination, is an infringement because such activity is beyond the implied authorization to use and sell a patented device. As the Supreme Court has stated:

> The decisions of this Court require the conclusion that reconstruction of a patented entity, comprised of unpatented elements, is limited to such a true reconstruction of the entity as to 'in fact make a new article,' after the entity, viewed as a whole, has become spent. In order to call the monopoly, conferred by the patent grant, into play for a second time, it must, indeed, be a second creation of the patented entity. . . Mere replacement of individual unpatented parts, one at a time, whether of the same part repeatedly or different parts successively, is no more than the lawful right of the owner to repair his property.

Aro Mfg. Co. v. Convertible Top Replacement Co., 365 U.S. 336, 346, 128 USPQ 354, 359 (1961) ("Aro I") (citations omitted). On the other hand, one does have authority to repair a patented device that he has purchased. This case raises the question whether the modification of the HP cartridges by ROT is repair, as the district court implicitly held, or is tantamount to reconstruction, as HP urges.

It is undisputed that HP sold and ROT purchased the Kukla and Stanley cartridges without restriction; HP has not alleged that ROT breached any contract affecting the transaction. When HP (or an agent with authority to sell) sold the cartridges, HP parted with the right to enforce any of its patents relating to the cartridges thus sold to exclude the purchaser from using or selling them. See Aro Mfg. Co. v. Convertible Top Replacement Co., 377 U.S. 476, 484, 141 USPQ 681, 685 (1964) ("Aro II") ("[I]t is fundamental that sale of a patented article by the patentee or under his authority carries with it 'an implied license to use.'") (quoting Adams v. Burke, 84 U.S. (17 Wall.) 453, 456 (1873)); United States v. Univis Lens Co., 316 U.S. 241, 249 (1942) ("An incident to the purchase of any article, whether patented or unpatented, is the right to use and sell it . . . ."); Mitchell, 83 U.S. (16 Wall.) at 547 (stating that where the sale is without

restriction, "the rule is well established that the patentee must be understood to have parted to that extent with all his exclusive rights, and that he ceases to have any interest whatever in the patented machine so sold and delivered").

HP correctly states that ROT's modification is not conventional repair. The caps on the purchased cartridges are not broken or defective. On the other hand, neither is ROT's modification a "reconstruction" of the patented combination. A reconstruction occurs after the patented combination, as a whole, has been spent, when "the material of the combination ceases to exist." Wilson v. Simpson, 50 U.S. (9 How.) 109, 123 (1850). While there is no bright-line test for determining whether a modification is a "reconstruction" sufficient to infringe a patent owned by the seller of the product, on the undisputed facts in this case, we agree with the district court that ROT has not reconstructed the cartridges. ROT's modification of the caps of HP's cartridges is more akin to permissible "repair" than to impermissible "reconstruction." See Kendall Co. v. Progressive Med. Tech. Inc., 85 F.3d 1570, 1575, 38 USPQ2d 1917, 1921 (Fed. Cir. 1996) (stating that "as long as reconstruction does not occur or a contract is not violated, nothing in the law prevents a purchaser of a device from prematurely repairing it"). While HP had the right to be free from competition from those who would reconstruct spent products, ROT did not do that. Even accepting that ROT's actions constitute a "making" of the accused cartridges, they were made from new and unused HP cartridges purchased from a legitimate source, and the property of ROT; the HP cartridges were certainly not spent. Furthermore, ROT does not replace any of the elements recited in the claims; the housing, printhead, standpipe, ink reservoir, and flexible strip are all original components of the purchased cartridges. Using the original housing, ROT only changes the way in which the cap of an unused, new cartridge is connected to the remainder of the cartridge. This modification allows ROT's customers to use the cartridges for the duration of the life of the patented combination, rather than be limited by the duration of the ink supply in the cartridge.

The Supreme Court decision in the case of Wilber-Ellis Co. v. Kuther, 377 U.S. 422, 141 USPQ 703 (1964), decided on the same day as Aro II, is instructive on this point. In that case, the patentee sued the purchaser of patented fish-canning machines after the purchaser modified the machines. As originally constructed, the machines packed fish into one-pound cans. The purchaser had six of thirty-five elements of the machines resized so that

the machines would pack fish into smaller five-ounce cans. Declining to treat the unrestricted sale of the machines as a license for use on one-pound cans only, the Supreme Court held:

> When six of the 35 elements of the combination patent were resized or relocated, no invasion of the patent resulted, for as we have said the size of cans serviced by the machine was no part of the invention; nor were characteristics of size, location, shape and construction of the six elements in question patented. Petitioners in adapting the old machines to a related use were doing more than repair in the customary sense; but what they did was kin to repair for it bore on the useful capacity of the old combination, on which the royalty had been paid.

Wilbur-Ellis, 377 U.S. at 424-25, 141 USPQ at 704-05. Likewise, ROT's modification of the original HP cartridges improved their usefulness by allowing ROT and its customers to use them for their own purposes. It was "kin to repair." We find HP's arguments attempting to distinguish Wilbur-Ellis unconvincing.

HP argues that the machines in Wilbur-Ellis had not reached the end of their intended life, whereas the intended and useful life of its cartridges ends as soon as a single reservoir of ink is depleted because at that point, print quality cannot be assured. It asserts that "Hewlett-Packard engineered the Kukla and Stanley cartridges so that no component would fail prior to delivery of all of the ink contained therein." While such engineering may be testimony to the quality of HP's product, and ROT's actions may affect HP's warranties, this argument does not support HP's legal position. HP's unilateral intentions cannot change the fact that ROT has only modified an unused cartridge that HP sold without restriction. HP fails to recognize the distinction between what it intended to be the life of the cartridge, as determined by the ink supply, and its actual useful life. As HP's assertion makes clear, the cartridges are specifically designed so that the ink is depleted not only before the patented combination as a whole is spent, but before any single component of it is spent (such as the printhead). Thus, the useful life of the patented combination is substantially longer than the life of a single reservoir of ink.

HP also argues that the boundary between "permissible repair" and "impermissible reconstruction" turns on the intention of the patentee. HP contends that it has clearly manifested its intent that the ink jet cartridges be

non-refillable. The package insert accompanying the cartridges suggests that the cartridges be discarded once they are empty; HP does not sell refillable cartridges, and HP does not sell ink refills. Because it has always manifested an intent that its cartridges be discarded, it argues, the creation of refillable or refilled cartridges are unauthorized acts which constitute an infringement of its patents. HP in effect argues that any change to a patented product that is not intended by the patentee constitutes reconstruction. In support of its theory, HP cites Wilson, 50 U.S. (9 How.) at 125-126, as establishing an "intent-of-the-patentee analysis" for determining whether conduct is to be considered a "repair" or a "reconstruction." We do not agree; HP has misread Wilson. Although at times speaking in terms of the intention of the inventor, the Court focused on the nature of the device sold, and specifically on the fact that the machine was designed such that one group of components, the knives, would wear out long before the remaining components:

> The proof in the case is, that one of [the inventor's] machines, properly made, will last in use for several years, but that its cutting-knives will wear out and must be replaced at least every sixty or ninety days.
>
> [If such a] part of the combination is meant to be . . frequently replaced, because it will not last as long as the other parts of the combination, its inventor cannot complain.

Wilson, 50 U.S. (9 How.) at 125-26. Although HP cites American Cotton-Tie Co. v. Simmons, 106 U.S. (6 Otto.) 89, 94 (1882), as additional support for its "intent-of-the-patentee" theory, the Supreme Court, in Aro I, referred to American Cotton-Tie by noting that "the fact that the [devices] were marked 'licensed to use once only' was deemed of importance by the Court." Aro I, 365 U.S. at 343 n.9, 128 USPQ at 358 n.9. Thus, absent a restriction having contractual significance, a purchase carries with it the right to modify as long as reconstruction of a spent product does not occur. See Mallinckrodt, Inc. v. Medipart, Inc., 976 F.2d 700, 24 USPQ2d 1173 (Fed. Cir. 1992) (stating that should "single use only" restriction be enforceable on remand, reuse of device would be a breach of contract and therefore unauthorized). The question is not whether the patentee at the time of sale intended to limit a purchaser's right to modify the product. Rather the purchaser's freedom to repair or modify its own property is overridden under the patent laws only by the patentee's right to exclude the purchaser from making a new patented entity. Each case turns on its own particular facts,

but a seller's intent, unless embodied in an enforceable contract, does not create a limitation on the right of a purchaser to use, sell, or modify a patented product as long as a reconstruction of the patented combination is avoided. A noncontractual intention is simply the seller's hope or wish, rather than an enforceable restriction.

HP's arguments based on decisions of this court are similarly unavailing. In Sage Products, Inc. v. Devon Industries, Inc., 45 F.3d 1575, 33 USPQ2d 1765 (Fed. Cir. 1995), we held that an inner container of a patented medical waste disposal system was effectively spent when filled and thus could be replaced or repaired without infringing the patent. In response to the patentee's argument that the inner containers were not spent, the court noted, inter alia, that the patentee admitted that it intended that customers replace the inner containers. 45 F.3d at 1578, 33 USPQ2d at 1767. The patentee's intent was relevant, not to limit use by the purchasers, but to show that the patentee expected the product to be repaired. Neither that decision nor other decisions of this court cited by HP suggest that a patentee's intent alone limits the scope of the implied license that accompanies the sale of goods.

Accordingly, even though HP clearly intends the filled cartridges which it sells to be discarded after a single use, HP cannot use the patent laws to impose restrictions on the cartridges' use after selling them unconditionally. The modification made by ROT, essentially replacing the type of seal holding the cap onto an unused cartridge, is not a "second creation of the patented entity" so as to constitute an infringement of HP's ink jet pen patents. See Aro I, 365 U.S. at 346, 128 USPQ at 359. Were we to rule in HP's favor in this case, we would be depriving ROT of the right to use and resell its own property, an unused product it purchased free of restriction, and enable HP to limit the use of a product it freely sold without restriction.

B. The '503 Ink Patent

HP argues that summary judgment of non-infringement of the '503 patent was improperly granted because the court ignored evidence of infringement proffered by HP, including "admissions" of infringement by two of ROT's ink chemists. We find no error in the district court's conclusion that, viewing the evidence in a light most favorable to HP, it has failed to meet its burden to show the existence of genuine issues of fact for trial. Regarding the "admissions," HP cites deposition testimony by a former ROT chemist in which the chemist stated that he believed that ROT's black ink refill "fell within the claims" of the '503 patent. However, during the same deposition and when questioned claim by claim, he could not identify a single claim that read on ROT's inks. He further explained in detail why the chemical compositions of ROT's inks did not meet each element of the asserted claims as he understood them. Upon questioning regarding the discrepancy in his testimony, the chemist explained that he did not understand the examining attorney's use of the phrase "fall within the claims" to mean that every limitation of each claim was met by the accused product. Thus, the chemist offered unrebutted testimony that the accused ink was not within the scope of the asserted claims. His earlier conclusory response, based on a misunderstanding of the question asked and immediately shown to be an inaccurate summary of his views, does not raise a genuine issue of material fact.

The other evidence cited by HP is the statement by an ROT chemist that ROT's president had told her on her first day of work that "there was a problem, there was patent infringement" regarding an ink jet ink formula developed by another chemist. This statement is hardly an admission that the accused products infringe the asserted claims of the patent at issue. HP has failed to provide any evidence that creates a genuine issue of fact concerning whether the accused products contain inks that are covered by the asserted claims of the '503 patent.

C. The Remaining Patents In Suit

The remaining nine patents allegedly cover various components of ink jet cartridges. ROT does not appear to dispute this. In its Statement of Undisputed Material Facts submitted to the district court, ROT admitted that "[t]he claims of [the patents in suit] claim either structure of the elements of the cartridges or methods of making same." However, ROT contends that its modification does not affect these elements, and HP does not allege otherwise. Rather HP argues that the modified cartridges are "new" devices

that infringe these patents as well. As previously discussed, this argument misses the mark. HP has not introduced any evidence to show that ROT's limited modification constitutes reconstruction of the patented cartridges.

With regard to the '295 patent, HP argues that ROT's activities infringe process claims directed to "providing" ink reservoirs with ink and "filling" ink reservoirs with ink. This argument is also unpersuasive. Unauthorized use of the cartridges covered by the apparatus claims would necessarily infringe the asserted process claims. As previously articulated, however, when a patentee sells a device without condition, it parts with the right to enforce any patent that the parties might reasonably have contemplated would interfere with the use of the purchased device. While HP may assert that it didn't intend that the cartridges be refilled, there was no agreement on that point. Moreover, a license was impliedly granted under the patent for the additional reason that it contained apparatus claims as well as process claims covering use of the cartridges. Accordingly, HP "authorized" the practice of any method claims in the '295 patent when it sold the cartridges unconditionally. Univis Lens Co., 316 U.S. at 249 (stating that "upon familiar principles the authorized sale of an article which is capable of use only in practicing the patent is a relinquishment of the patent monopoly with respect to the article sold"). Finally, HP has not met its burden of showing the existence of an issue of material fact with regard to the asserted method claims of the '295 patent.

CONCLUSION

The district court did not err in granting ROT's motion for summary judgment of non-infringement of all twelve asserted patents and in denying HP's contrary motion regarding two of the patents. HP sold ink jet cartridges without condition or restriction. ROT lawfully purchased the cartridges and modified them in a manner that was more akin to permissible repair than to impermissible reconstruction. Therefore, ROT's modification and sale of the cartridges did not infringe the asserted claims of the two "ink jet pen" patents or the asserted process claims allegedly covering the use of the cartridges. Because it is undisputed that the modification did not effect a reconstruction of any claimed subject matter in the nine patents allegedly covering components of the cartridges, these claims were not infringed as well. In addition, the district court did not err in holding that HP failed to

raise a genuine issue of fact regarding infringement of the asserted ink patent. Accordingly, the decision of the district court is affirmed.

AFFIRMED