CHAPTER 5

INNOVATIVE PATTERNS

5.1 PREAMBLE

This chapter provides the various innovative patterns with corresponding hardware and software examples. It also describes the steps involved in applying the innovative patterns to a particular case study and the results are presented and discussed by means of graphs and charts (This chapter was written based on the publications done in the IJCSNS, South Korea, 2008, Vol. 8, No. 7, pp. 314-318 and JCIT Journals, Korea, 2008, Vol. 3, No. 4, pp. 54-58).

5.2 INNOVATIVE PATTERNS

To overcome the disadvantages of EATAM, innovative patterns are introduced here. At the core of our process are five innovative patterns. These “templates of innovation” have emerged from our historical analysis of product development trends. Our research indicates that the more successful product innovation fits into at least one of these five patterns. Indeed, we have found that the patterns can help predict the emergence of new products before the appearance of signals indicating the market demand (Jacob Golden et al 2003). The Innovative Patterns are represented in Figure 5.1.
5.2.1 **Subtraction Pattern**

While introducing new patterns, the marketers tend to eliminate the complexities in the old version thereby adding some interactive and innovative Add-on features that would enhance its performance and at the same time satisfy the customer needs better.

5.2.1.1 **Hardware example**

The successful application of this pattern was demonstrated by The Philips Consumer Electronics Ltd. They removed the local display and all the control buttons on its DVD player. They kept just one button for the most common functions. Controls for the remaining operations were moved to the GUI and made accessible by a button on the remote control. This resulted in reduced clutter, a sleek and elegant design and gave them an edge over their
competitors. This is about the slim line Q series DVD players (Jacob Golden 2003).

5.2.1.2 Software example 1

Everyone would have browsed the Job Portal. Users found it difficult because each and every detail of the resume had to be typed. Due to this, there was wastage of time and unwanted errors occurred. These demerits were analyzed and a better replacement was made by a new website which is used currently. Here, applicants can upload their resumes directly in a jiffy instead of wasting their time in typing the resume. The subtraction patterns got a tremendous response and satisfied the needs of the customers. While this is a perfectly logical approach, it can result in those incremental improvements that have an impact on customers.

5.2.1.3 Software example 2

Many practices in software engineering which we have come to perform in designing software architectures implicitly fall under the subtraction pattern.

While normalising a database we remove a version of the database which occupies more space and replace it with the more light-weight and efficient normalized database.

In an Inventory Management Project, the Subtraction Pattern can be applied apart from the obvious Normalization of the database, using Web Services. Using Web Services, the heavier modules, which would require a lot of resources to execute, can be moved to a web server. The modules are removed from the client and installed on a web server, which leads to a reduction of the execution code on the client side. The client sends the request
and the arguments to the server, which executes the commands and sends back the result to the client.

5.2.2 Multiplication Pattern

The second pattern represents a very different approach to innovation. This is the prime logic behind the multiplication pattern: here, the existing components or features are untouched, but another copy of these features is made. The objective is to go beyond a mere quantitative change and achieve a qualitative change.

5.2.2.1 Hardware example

The application of this pattern is not limited to a quantitative replication and focuses on subtle qualitative refinements. An elegant example for the success of this pattern is illustrated by The Gillette Double Edge Razor. The extra blade is set at a slightly different angle. It raises the whiskers so that the other blade can cut cleaner.

5.2.2.2 Software example

The Google search engine serves as a classic example for this. Initially it had just a simple search engine, with less features and wide range of results, where the users used to while away their time in searching for information. Now the search engine contains an added new feature called “Advanced Search” where one can filter his/her query and reduce the time by specifying appropriate fields such as date, file type, range etc. This advanced search not only does the job of simple search, but also provides more features to narrow down the range of the search results. The user can find what he is looking for, by this method.
5.2.3 Division Pattern

One can use the division pattern to split an existing product into many component modules. There is a change in the perspective which may lead to the reconfiguration of those modules in an unanticipated way – or even keep the modules separate in a manner that offers an unexpected yield. The speciality of division is that each module preserves the characteristics of the whole.

5.2.3.1 Hardware example

This pattern can be applied in a number of ways. Physical division (The product is cut along physical lines), Functional division (Separating components with different functions), and preserving division (Each part preserves the characteristics of the whole even after division) are some of them.

Physical division has been successfully applied to car stereos. The front panel and operating controls are integrated as a single unit and kept separate from the rest of the unit. Then the panel can be removed from the car when unoccupied reducing the probability of theft.

The preserving division approach had been used by Caesarea Creation Industries, an Israeli company making house-hold rugs. They divided a standard sized rug into ruglets adding modularity. Each ruglet can be used separately or fitted together to form a large rug.

5.2.3.2 Software example 1

Yahoo, known for its wide range of usage all over the globe, had all the utilities integrated into a single domain. Those utilities were yahoo messenger, search engine, mail, sports, and movies. Now, they have been
separated into individual modules. The main advantage of this method is that even if the “yahoo.com” is down, the user can still browse the various areas using their individual modules.

5.2.3.3 Software example 2

The software example for division pattern is multithreading. In multithreading, one large process is broken into smaller processes which are fed to the processor based on a scheduling algorithm, thereby increasing the throughput.

5.2.4 Task Unification Pattern

According to this method one can understand pattern innovation by assigning a new task to an existing product or its constituent environment, thereby fusing two tasks in a single component. The basic rationale for this bundling of tasks is, if a single component is sufficient for performing the task of the pattern and its environment, why not just see whether it can be made to do double duty.

5.2.4.1 Hardware example

Here, a new task is assigned to an existing component or environment. A beautiful example for task unification is the defrosting filament in an automobile wind shield doubling up as a radio receiver antenna.

5.2.4.2 Software example 1

The best examples for task unification are the various antivirus softwares available. For an instance consider bitdefender total security, in this
they have merged the antivirus feature with the antispyware and other system
tune up software thereby providing a greater customer satisfaction.

5.2.4.3 Software example 2

A classic example for task unification would be Borland C which
used to compile only ‘C ‘Programs. The newer version Turbo C contains the
files required for both C and C++, so that both C and C++ codes can be
compiled in the same environment. An even more specific example would be
Microsoft VC++, which can execute all codes that run on a common platform.
By creating patterns which provide double benefits, a huge customer base is
created and an incredible level of innovation is achieved.

5.2.5 Attribute Dependency Change Pattern

This pattern mainly involves the dependent relationship between
the attributes of a product and those of its immediate environment. The
pattern can be made more adaptable to the given environment. One can also
create dependencies that exist between two unrelated attributes of a single
pattern. The attribute dependency pattern often generates what later seem like
inevitable patterns.

5.2.5.1 Hardware example

The application of this pattern tries to bring about a differentiation
involving the relationship between the attributes of a product and those of its
immediate environment. An example is given below.

Men and women had been using the same type of razor before the
Gillette Company realised the potential of designing a model exclusively for
women. Today it is taken for granted.
5.2.5.2 Software example

Windows Media Player is mainly used for playing audio and video files. This media player identifies the file format and plays the file accordingly. That is if the extension is .mp3, then it identifies that it is a audio file and plays the file in the audio format. If the extension is .avi, then it identifies that it is a video file and plays it in the video format. In this way it adapts to the given environment and satisfies the needs of the customer.

5.3 PROCEDURE FOR APPLYING INNOVATIVE PATTERNS

**Input:** The software architecture to be refined.

A set of innovative patterns $a = \{\text{subtraction, multiplication, division, task unification and attribute dependency change}\}$.

**Output:** Improvement of the quality metrics and thereby the overall performance and efficiency of the specific architecture under consideration.

Step 1: Identify the business goal, major stakeholders, the relevant technical and managerial constraints such as operating system, hardware and architectural patterns, quality requirements and the time for design and documentation.

Step 2: Collect and prioritize the scenarios in the architecture and analyze the architectural approach.

Step 3: Identify the quality attributes relevant to the architecture.

Step 4: Apply the innovative patterns one by one iteratively on the architecture under consideration.
Step 5: Refine the architecture based on innovative patterns and how each one affects the particular quality attribute.

Step 6: Generate the final result and submit to the customer for feedback.

Step 7: Repeat steps 2 through step 5 if necessary based on the customer feedback.

By applying the innovative patterns, the typical issues that are under investigations are as follows:

1. Are all stakeholders considered?
2. Have all the requirements been identified?
3. Is the architectural solution being provided, appear rational?
4. Are the documents well managed?

These issues can be verified by using the above algorithm and the results are discussed with different Case Studies.

5.4 CASE STUDY 1

Let us look at four unique and distinct projects, namely,

1. Financial Management with 1000 function points
2. ERP with 1500 function points
3. Health Care with 2500 function points
4. Stock Trading with 4000 function points
5.4.1 Financial Management

Financial management is the organizational function concerned with the efficient allocation and effective use of available financial resources to achieve optimal results. Budgeting, accounting and other financial measures, including accurate and timely reporting systems are a valuable means of providing management with the financial data necessary for objective analysis and evaluation of current programs and activities. They also provide the essential data for realistic planning and control, and for effective decision making. Effective financial management requires the assistance and cooperation of all the departments within the Government and the various Government organizations.

One of the most vital components of any financial management systems is budgeting which generally includes the following: Economic indicators and data for the previous year and the outlook for the budget year. Financial information as to the fiscal performance for the previous year and the forecast for the budget year. Program impacts and expectations.

The Budget is supported by the Estimates which include details of gross expenditures for the various departments’ activities, revenue projections, capital account result, current account result, net result and borrowing requirements for the budget year. Also included in the Estimates are various charts, graphs, and information as to public debt and other supplementary information. The Estimates include statutory/non-statutory expenditure details.

5.4.2 Enterprise Resource Planning

Enterprise solutions provide a centralized framework for all the data and processes of an organization. It integrates all aspects of a business
from planning to inventory control, manufacturing, sales, marketing, finance, customer service and human resources. Our enterprise solutions enable the integration of all the business activities of an organization, thereby improving operational efficiency.

On the financial sector the system utilizes an integrated financial system with all information and transactions flowing into the general ledger. The ERP system provides unprecedented reporting capabilities and access to information. The ERP system allows the staff to work more efficiently, more flexibly and reduce reliance on paper forms. An electronic, workflow-enabled system greatly improves the processing of purchase requisitions along with other documents. Users can track their requisition status as it flows through the system to Purchasing. Enhanced Purchasing and Accounts Payable reporting tools give departments’ access to information integrated into one financial system, with everything flowing into the general ledger.

Accounts Payable will have the ability to improve and control payments to vendors. Payment functions can be streamlined and automated and this results in reduced processing time and increased efficiency. Contractual payment requirements and early pay discounts outside standard payment terms and electronic payment processing by EFT, ACH and wire transfers can be tailored to specific vendors. Result: Improved vendor relationships. Enhanced payment controls for areas such as price verification, duplicate invoicing, and automated bank reconciliation.

With an ERP System, the staff can easily access information any time, any place from a single location. It replaces aging, non-integrated core legacy systems that are costly to support and maintain. It also Improves access to accurate and timely information and creates more self-service opportunities through a user-friendly Web-based interface.
A single integrated data repository provides superior reporting and data analysis capabilities and promotes information sharing. Electronic approval processes reduce paper use and reliance on paper forms, eliminate redundant data entry tasks, and shortens the timeframe for procuring goods and services, eases the creation and utilization of world-class best practices to streamline workflow processes, and increase productivity and efficiency.

5.4.3 Health Care

As an example scenario we consider a web based software solution in the healthcare domain.

A website, which connects a group of doctors and gives them a forum to interact, both at the personal and public level, where they can discuss diseases and treatments, receive and offer advice, improve their knowledge levels and even access a resume database, where pharmaceutical and medical insurance companies can endorse their services and glean useful information from the activities happening on the site.

Doctors from various practices can register and avail special member-related services online. They can share knowledge in chat sessions and forums, polls and surveys, knowledge that will be useful not just to fellow-doctors but also to pharmaceutical companies and other partners in the health-care industry.

A doctor can post details of his patients without revealing personal information about the patient and ask for advice from other doctors through a private chat or job seekers can post resumes and view job postings online. Doctors can post documents that can be edited and shared through private chat or messaging.
The site can put affiliate marketing to good use. Pharmaceutical companies, medical equipment suppliers or doctors can put up valuable medical content that can serve as crowd-pullers and thereby advertise their services or products. A typical health care solution has the features described below.

A community for doctors, an advertising forum for the healthcare industry (pharmaceuticals, medical equipment and insurance), Facility to upload, edit and share information, Recruitment (Post and apply), Shopping (affiliate marketing and advertising), Member profiling/CV, Valuable Content, Polls/Surveys/Chat forums and Personalized Newsletters.

5.4.4 Stock Trading

The project was to develop an integrated solution designed specifically for the Stock Exchange Board. The primary objective was to address an important and compelling need of investors on the move, i.e. making timely investment and trading decisions using their handheld devices. The system required that a link with globally reputed content providers, which are partners of the Stock Exchange Board, be made available. This was to provide “Anytime, Anywhere” access to customers. The application had to provide comprehensive market information, analytical tools and recommendations. The challenge was to integrate the ability to conduct transactions over the exchanges in a secured manner from all major types of handheld devices like PDA’s and WAP phones.

It was made clear by the client that the system had to incorporate a host of features to provide investors with powerful decision-making and trading tools on their handheld devices. The analytical tools were to be designed intuitively to provide investors with easy and configurable tools for performing a fundamental analysis. Another requirement was that based on
the individual preferences, investors should be able to personalize the information collected from the content providers on their handheld devices.

It was important to enable secure trading over handheld devices. To meet this goal, end-to-end security based on PKI/WPKI concepts were to be incorporated into the solution. This was to instil confidence in all the stockholders that transactions cannot be fraudulently generated or altered. It was also necessary to provide that transactions are legally binding and the confidentiality of private information is adequately protected.

5.5 RESULTS AND DISCUSSION

In order to evaluate the merits and demerits of the proposed approach (use of innovative patterns for software architecture) four information system projects at the enterprise level were taken up and a detailed analysis was carried out. A host of relevant parameters (analysis time, analysis level bugs, cost, maintainability, adaptability, reliability, scalability, cohesion and coupling) and their variations were compared using both ATAM approach and innovative patterns approach.

The result of the study is presented below in detail.

5.5.1 Analysis Time

The first criterion that we considered was analysis time. From this, we see that there is a reduced analysis time for the development of the product as there is a reduced number of components by the application of the subtraction pattern and the task unification pattern.

The graph plotted below illustrates the relationship between the Analysis time (in units of months on y axis) and function points (x axis) and
presents a comparison between the ATAM and innovative pattern approach as shown in Figure 5.2(a) and (b).

![Comparison between ATAM and Patterns](image)

**Figure 5.2 Analysis time**

The overall cost of the product is significantly reduced in the pattern approach.

The cost of the products can be calculated with the formula:

\[
\text{Cost of the product} = \text{Human resource required for the product} \times \text{Time required for analysis} \times \text{The cost per unit time}
\]
5.5.2 Analysis Level Bugs

The next criterion considered is the analysis level bugs. It was seen that there was a reduced number of bugs in patterns than in ATAM. This was achieved due to the refinement done by the application of the subtraction and task unification pattern. The graph plotted below shows the relationship between the analysis level bugs (in units of number of bugs encountered on y axis) and function points (x axis) and presents a comparison between the ATAM and innovative pattern approach ass shown in Figure 5.3(a) and (b).

![Graph showing analysis level bugs vs function points for ATAM and Patterns.](image)

(a)

![Bar chart showing analysis level bugs for ATAM and Patterns.](image)

(b)

Figure 5.3 Analysis level bugs

A significant cost factor is associated with analysis level bugs which manifests in terms of the time spent in uncovering and rectifying the bugs during analysis.
5.5.3 Cost

The next criterion that we considered was the cost required to build the product. It was observed that there was a significant reduction in the cost of development of the product by the implementation of the subtraction pattern.

The graph plotted below illustrates the relationship between the cost (in terms of units of $1000 on y axis) and function points (x axis) and presents a comparison between the ATAM and innovative pattern approach as shown in Figure 5.4(a) and (b).

Figure 5.4 Cost
Cost of the product  =  Human resource required for the product × Time
required for analysis × The cost per unit time

5.5.4 Maintainability

It is the characteristics of design and installation expressed as the
probability that an item will be retained for a given period of time.
Maintainability is also defined as the percentage of total cost that is required
to maintain the product (Banker et al 1998). It was seen that the
maintainability of the system using patterns was significantly higher than that
of ATAM. This was because of the application of the subtraction and task
unification pattern (Lee and Hsu 2002).

The maintainability is measured as,

\[
\text{Maintainability} = \frac{\text{Number of application scenarios to which the system correctly adapted}}{\text{Total number of application that contains either false or require modifications}} \times 100
\]

The graph plotted below shows the relationship between maintainability (in terms of percentage on y axis) and function points (x axis) and presents a comparison between the ATAM and innovative pattern approach as shown in Figure 5.5(a) and (b).
Adaptability

The next criterion that was considered was adaptability. Adaptability is the feature provided by the system. From a software architecture point of view adaptability represents the degree of ease with which modifications can be accommodated. It directly depends on the degree of coupling. Higher degree of coupling will lead to lower degree of adaptability. Adaptability is the ease with which the user adapts to the change in the system. It was seen that the adaptability of the system was higher than that of ATAM.
Number of applications to which the system properly adapted

\[
\text{Adaptability} = \frac{\text{Number of applications to which the system properly adapted}}{\text{Total number of application scenarios}} \times 100
\]

The graph plotted below shows the relationship between adaptability (in terms of percentage on y axis) and function points (x axis) and presents a comparison between the ATAM and innovative pattern approach as shown in Figure 5.6 (a) and (b).

![Graph showing Adaptability vs Function Points](image)

**Figure 5.6 Adaptability**

### 5.5.6 Reliability

The next criterion that we considered was reliability. Software Reliability is the probability of failure-free software operation for a specified period of time in a specified environment. The reliability of a software as an end product will be influenced by the reliability of the processes used during the analysis phase. Here, we looked at MTTF (Mean Time To Failure).
Reliability is defined as the number of bugs that is found in the design phase. It was seen that the reliability of the system was higher in this pattern than in ATAM.

$$\text{Reliability} = \frac{\text{Duration for which the software worked without failure}}{\text{Total Duration}} \times 100$$

The graph plotted below illustrates the relationship between the cost (in terms of units of probability of bugs in design please on y axis) and function points (x axis) and presents a comparison between the ATAM and innovative pattern approach as shown in Figure 5.7 (a) and (b).

Figure 5.7 Reliability
5.5.7 Scalability

The next criterion that we considered was scalability. Scalability is the ability of the system to scale up or scale down. The degree of scalability can be quantified in terms of the cost to be incurred for a specific scale up. This will essentially depend on the specifics of the architecture. It was seen that the scalability of the system was higher in the patterns than in ATAM.

The graph plotted below illustrates the relationship between scalability (in terms of unit of 100$ on y axis) and function points (x axis) and presents a comparison between the ATAM and innovative pattern approach as shown in Figure 5.8 (a) and (b).

Figure 5.8 Scalability
5.5.8 Cohesion

The next criterion we considered was Cohesion. Cohesion is measured as to how strongly related the various responsibilities of a software model are. A software product displays a higher degree of cohesion if the various component modules function with a higher degree of independence with respect to each other.

We have adopted for the following definition for cohesion:

\[
\text{Cohesion (Module wise)} = \frac{\text{No. of independent functions in the module}}{\text{No. of total functions in the module}}
\]

\[
\text{Cohesion (overall)} = \text{Average of individual module values}
\]

The cohesion of the product developed was higher in patterns than that of ATAM.

The graph plotted below illustrates the relationship between the Cohesion (in terms of percentage on y axis) and function points (x axis) and presents a comparison between the ATAM and innovative pattern approach as shown in Figure 5.9 (a) and (b).
5.5.9 Coupling

The final criterion that was considered was coupling. Coupling is the degree in which each module relies on each one of the other modules. It was found that applying innovative patterns resulted in a significant reduction in the degree of coupling.

We have adopted the following definition for coupling:

\[
\text{Coupling (Module wise)} = \frac{\text{No. of dependent functions in the module}}{\text{No. of total functions in the module}}
\]

\[
\text{Coupling (overall)} = \text{Average of individual module values.}
\]
The graph plotted below illustrates the relationship between the coupling (in terms of percentage on y axis) and function points (x axis) and presents a comparison between the ATAM and innovative pattern approach as shown in Figure 5.10 (a) and (b).

![Graph](image1)
(a)

![Bar Graph](image2)
(b)

**Figure 5.10 Coupling**

The above results clearly show the overall performance of innovative pattern approach is definitely better than ATAM approach. After the detailed analysis the inferences drawn are summarised in the next section below.
5.6 SUMMARY AND CONCLUSION

From the above results and discussions we come to know that innovative patterns play an important role in enhancing performance of the evaluation of software architectures. A set of important parameters (analysis time, analysis level bugs, cost, computational complexity, maintainability, adaptability, reliability, scalability, cohesion and coupling) were analysed and it was observed how the application of innovative patterns bring about variations in their values. We could see that the optimisations performed by applying innovative patterns resulted in a significant improvement in performance.