Modeling and Analysis: Life Cycle Models

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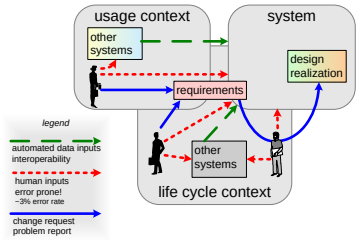

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Abstract

Products and enterprises evolve over time. This presentation explores the impact of these changes on the system and on the business by making (small and simple) models of life cycle aspects.

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1 Introduction

Life cycle modeling is mostly modeling expected changes during the life cycle and the impact of these changes. We will provide an approach to make life cycle models. This approach is illustrated by means of a web shop example.

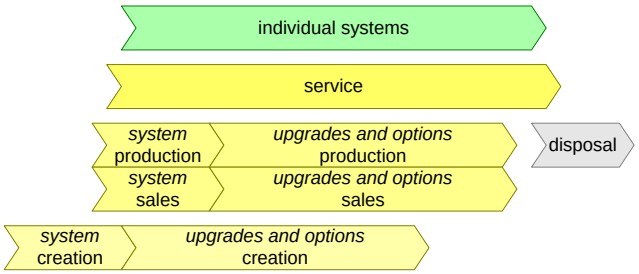

Figure 1: Product Related Life Cycles

Several life cycles are relevant. Figure 1 shows the related life cycles of product, option and upgrade *creation*, *production* and *sales*, the systems themselves, and the disposition.

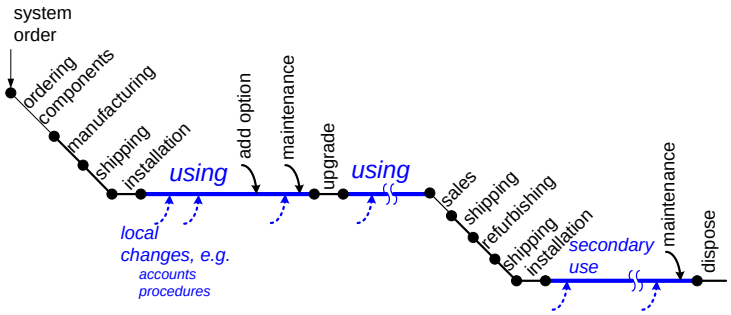

Figure 2: System Life Cycle

Figure 2 zooms in on the life cycle of individual system instances. Components are ordered and assembled into systems. The real use of the system starts after the system has been shipped and installed. During the use of the system many things happen to the system. The users themselves make small changes, such as adding or updating user accounts or procedures. Options can be added to the system and the system is maintained by service. Some systems are refurbished when they get older to be used again at some different location. Finally the system has to be disposed.

This paper belongs to the modeling and analysis series. It uses the same case example and overall approach.

2 Life Cycle Modeling Approach

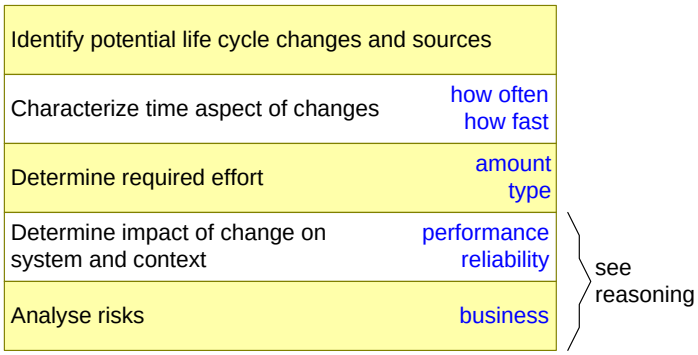

Figure 3: Approach to Life Cycle Modeling

Figure 3 shows a step-wise approach to make life-cycle models. The following steps are performed:

Identify potential life cycle changes and sources

Characterize time aspect of changes How often do these changes occur, how fast must be responded to these changes?

Determine required effort , the amount and the type of effort.

Determine impact of change on system and context for instance by using qualities, such as performance, reliability, security, cost, et cetera.

Analyse risks for the business. For instance, what is the cost of being several hours or days too late?

The impact and risks analysis is not elaborated in this paper, see *reasoning* and *analysis* papers.

During the life cycle, many elements may change, for example business volume, product mix, product portfolio, see Figure 4 for more examples. The amount of changes depends strongly on the type of business. For example a real estate portal is selling unique products with a lot attribute data per product. A music web shop, such as iTunes, at the other hand is selling the same product many many times. Figure 4 shows more variations of web sites.

The source of a data change influences the impact of such a change. A fundamental difference is data input from automated sources, such as data bases of content providers, versus data input by humans. Human inputs are very error prone. About 3 out of 100 human actions are erroneous. Luckily humans are

Figure 4: What May Change During the Life Cycle?

also very flexible, so many errors are repaired immediately. Nevertheless, many errors in the human inputs slip through and enter the system. The amount of errors in automated inputs depends on the data quality of the source and on the degree of interoperability ("level of mutual understanding") between the providing and receiving systems.

Figure 5 shows possible sources of changes from the usage context and life cycle context. Note that several human stakeholders can also generate problem reports or change requests, resulting ultimately in changes in of the design and realization of the system. Typically the response on problem reports must be fast (days or weeks), while the change request response is normally much slower (months or year). These response times are also a function of the business. For example in the world of the entertainment industry, where television shows use cell phone for interactive inputs, may suddenly require change request response times of days or weeks, rather than months.

Figure 6 zooms in one step further on changes that impact the web server of the web shop example. The changes in content are prepared outside of the production system. Most content changes will be provided by different content providers. For example publishers will provide most new books and related attributes for book shops. Human interaction will be limited to selection and the addition of sales information. Nevertheless we should be aware that even the automated input has its quality limits and originates somewhere from humans. Two other sources of changes are configuration related:

the *shop* **configuration** , for example roles, accountabilities and responsibilities of the staff

the *system* **configuration** , for example what servers are used, how are functions and resources allocated.

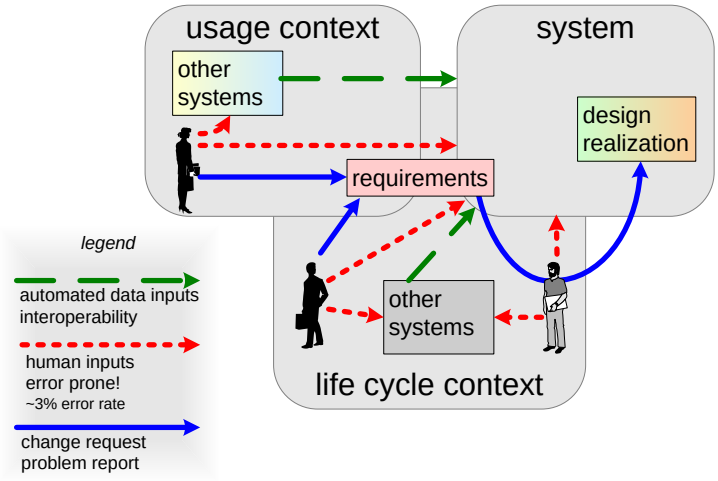

Figure 5: Simple Model of Data Sources of Changes

We have observed that configuration changes are a frequent source of reliability and availability problems. In terms of the popular press this called a computer or software problem. The last source of change in this figure is the behavior of the customers. A sudden hype or fashion may cause a very specific load on the system.

The modeling becomes much more concrete if we are able to quantify the number of changes. Figure 7 shows as an example the quantification of the number of books that is published per year. This data, from wikipedia, shows that UK and USA both publish more than 100k new books per year, together these two countries publish more than 1000 new books per day! The same data source provides data for many different countries. This illustrates the geographic impact on the quantification. India is still a small producer of books, but with more inhabitants than the UK and USA together, it can be expected that this will increase significantly. Note that this short discussion about India is a discussion of a second order effect: the change in the rate of change.

Wikipedia also provides data on the sales frequency of books. The interesting notion of the *long tail* is explained. In the case of book sales the total volume of very popular books is smaller than the long tail of many books with small individual sales. The characteristics of a book shop of popular books is entirely different from a book shop selling a wide variety of less popular books.

Figure 8 provides numbers related to the potential change in the customer base. This figure shows the number of broadband connections in China and India. If people connected to broadband are most probable customers of a web shop, then these numbers provide an indication of a potential shift in the customer base. Note that the amount of broadband connections in China increases with 25% per quarter, while this increase is more than 100% in India. The current situation is that very

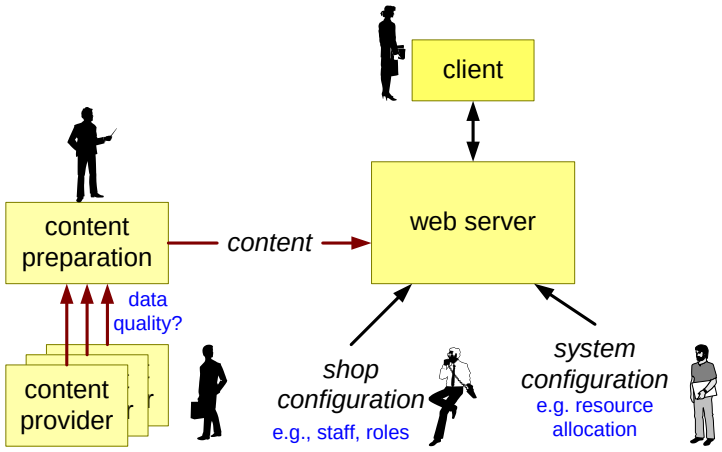

Figure 6: Data Sources of Web Server

few Indian people are potential web shop customers, but this number doubles every quarter! Note that the sales volume of the web shop is not only determined by the customer potential. Also market share growth and extension of the product portfolio will increase sales volume and customer base. A web shop in India might start very small and low cost, but it might have to scale up very rapidly!

The growth in the number of customers will trigger other changes:

What is the impact on system and infrastructure? The dimensions of the system have to be adapted to the changed load. In scaling thresholds occur where a more fundamental change is triggered. For example from a single multi-purpose server to several dedicated servers.

What is the impact on CRM (Customer Relation Management)? This might be a trivial function for a few thousand customers, but with tens or hundreds of thousands of customers more support might be necessary.

What is the impact on customer, sales support staff? More customers often has as a consequence that more staff is required: more customer support and more sales managers. An increase in staffing may also trigger changes in the system itself.

Once changes are identified we can analyze the propagation of these changes, as shown for the customer base. Changes trigger new changes. Figure 9 formulates a number of questions to look at this ripple through effect:

How much time/effort is needed for content updates? see below for elaboration.

How much staff is needed? And how many staff and role changes are to be expected?

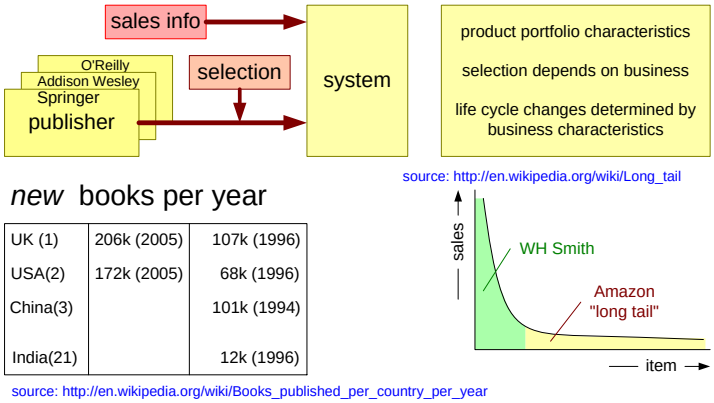

Figure 7: Example Product Portfolio Change Books

What is the impact of errors in content updates? So what is the impact on system quality and reliability? What is the process to prevent and cope with errors?

How many errors can be expected? Make the problem more tangible.

What is the impact of content updates on server loads? Do we have to scale the server configuration, due to changes in the content updates?

We need a simple model of the update process to estimate the amount of effort to change the content. Figure 10 provides such a simple model:

- every change is a sequence of 4 steps:
  - review input
  - select information to be used
  - design layout and apply cosmetics or “styling”
  - check in of the change, an administrative step

  Automated checks will take place concurrently with these steps, ensuring syntactically correct input.
- every change is verified by inspection: the implementation and the result are inspected.
- the complete set of changes is committed.

This simple process model can be used to make an effort model. If we substitute numbers in the formula derived in Figure 10, then we can explore the impact of the number of changes on effort and staff size.

internet: broadband penetration

	Q1 '04	Q2 '04	growth in Q2 '04
Asia Pacific total	48M	54M	12.8%
China	15M	19M	26.1%
India	87k	189k	116.8%

http://www.apira.org/download/world_broadband_statistics_q2_2004.pdf

What is the expected growth of # customers?
What is the impact on system and infrastructure?
What is the impact on CRM (Customer Relation Management)?
What is the impact on customer, sales support staff?

Figure 8: Example Customer Change

The business context, the application, the product and it's components have all their own specific life-cycles. In Figure 11 several different life-cycles are shown. The application and business context in the customer world are shown at the top of the figure, and at the bottom the technology life-cycles are shown. Note that the time-axis is exponential; the life-cycles range from one month to more than ten years! Note also the tension between commodity software and hardware life-cycles and software release life-cycles: How to cope with fast changing commodities? And how to cope with long living products, such as MR scanners, that use commodity technologies?

Note that the web shop content life cycle may be shorter than one month in the health care equipment example. Content life cycles may be one day or even shorter.

One way of modeling and analyzing the consequences of changes is by following the qualities. As an example, Figure 12 zooms in on the security aspect of the web ship example. The following questions can be analyzed:

What is the security model? In the diagram it is shown that different security domains are used:

- public internet where the clients are connected
- the production domain with enhanced access control through gateways. The external world has limited access to interact with the production environment of the web shop.
- a very secure intranet environment, where web shop content prepa-

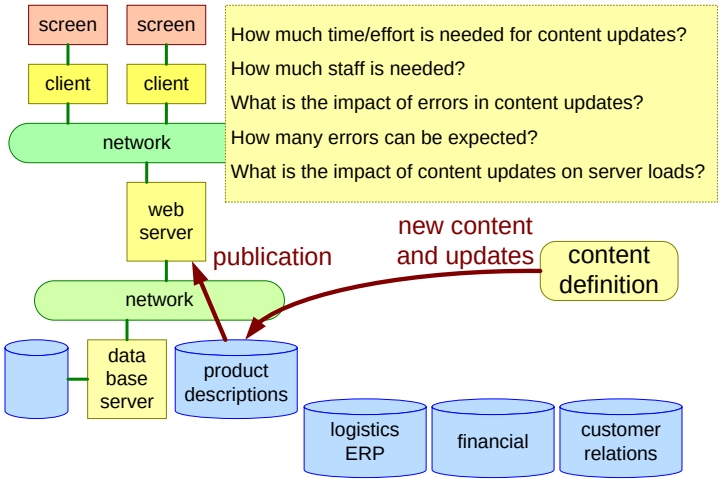

Figure 9: Web Shop Content Update

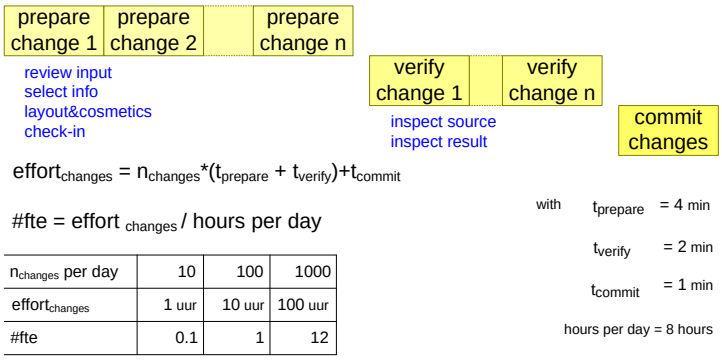

Figure 10: Web Shop Content Change Effort

ration and web shop management takes place.

What is the impact on server loads? The layers of security and the security based allocation of functions and data may impact the load of the servers.

What is the impact on staffing? The processes to ensure security will have impact on the way-of-working of the staff and the amount of work.

What is the impact of changes in staff? The staff itself has a significant impact on overall security. Changes of the staff itself will trigger second order effects, such as screening and authorization work and blocking moved staff.

What is the impact of changes on security? Any change somewhere in the system

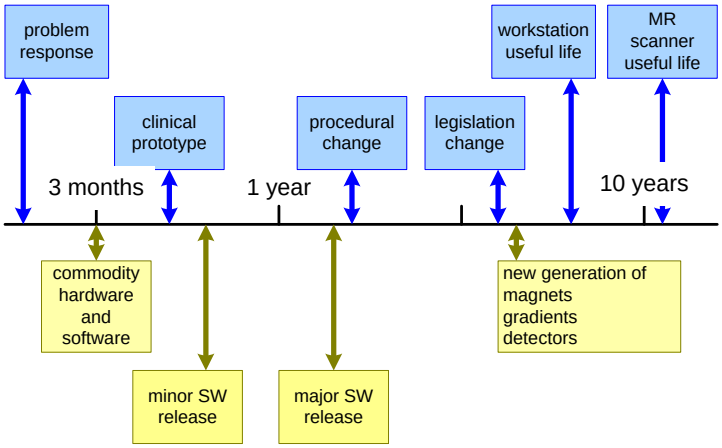

Figure 11: Life-cycle Differences for health care equipment

might have a side effect on overall security. Security concerns will create a continuous overhead for systems and staff.

Figure 13 shows an example of reliability modeling. *this needs to be elaborated GM*.

References

[1] Gerrit Muller. The system architecture homepage. `http://www.gaudisite.nl/index.html`, 1999.

History

Version: 0.7, date: 7 December, 2007 changed by: Gerrit Muller

- added Life Cycle Diagrams

Version: 0.6, date: 8 March, 2007 changed by: Gerrit Muller

- added client level changes

Version: 0.5, date: 6 February, 2007 changed by: Gerrit Muller

- changed order of slides
- added content change effort
- added preliminary reliability example
- added text version
- changed status in preliminary draft
- defined logo

Version: 0.4, date: 5 February, 2007 changed by: Gerrit Muller

- changed diagram with sources of changes
- added content update example
- added security example

Version: 0.3, date: 30 January, 2007 changed by: Gerrit Muller

- added input sources

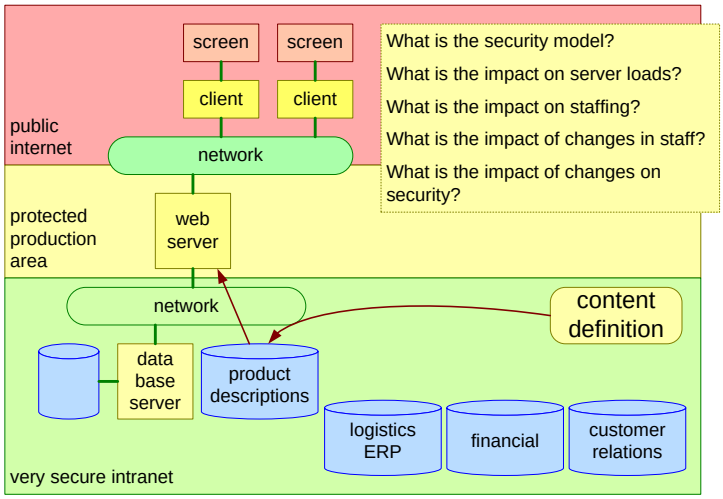

Figure 12: Web Shop Security and Changes

new faults = average fault density * #changes

#errors = $\sum_{\text{faults}}$ f(severity, hit probability, detection probability)

	severity	hit probability	detection probability
Jansen iso *Janssen*	low	high	low
operator iso *sales repr*	high	high	medium

Figure 13: Web Shop Reliability and Changes

- added book example
- added customer example

Version: 0.2, date: 12 January, 2007 changed by: Gerrit Muller

- added Time Scale Model for Changes

Version: 0.1, date: 5 January, 2007 changed by: Gerrit Muller

- added a list of questions

Version: 0, date: 4 January, 2007 changed by: Gerrit Muller

- Created, no changelog yet