Architecting and Standardization

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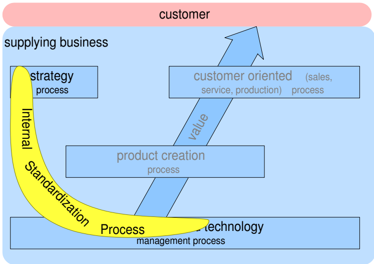

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Abstract

Many products today are developed for highly dynamic markets while the products and functions get more and more integrated. The product and service realization is based on fast changing technologies that come together in complex value chains. The challenge for modern companies in innovative domains is to survive in this dynamic world.
In this paper we explore the contribution of architecting and standardization to the company success. We look at the *why*, *when*, *who* and *how* questions of standardization and at the role of architecting in the standardization process.

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1 Introduction

One of the main challenges for companies today is to survive or better strive in innovative domains. Both market and technology developments are fast moving, while at the same time the level of integration increases. The value chain from suppliers and manufacturers to customers get more complex and dynamic as well. The globalization causes near ad hoc allocation of production and logistics functions. For product creation globalization also causes the involvement of many globally distributed partners. All of this takes place in a network of evolving strategic coalitions, where the financial stakes are huge because of the global scale. Figure 1 visualizes this problem statement.

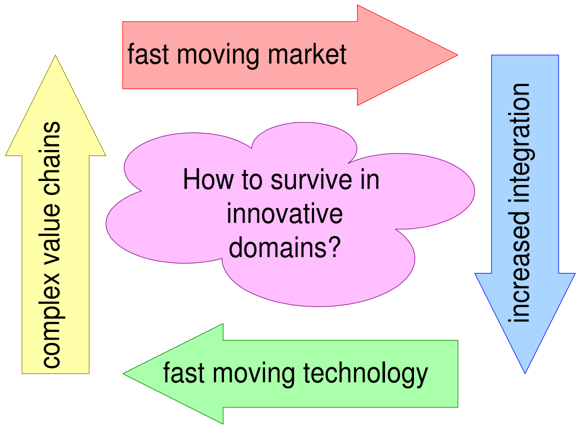

Figure 1: Problem Statement

The short and simple solution provided for this challenge is:
By being the fittest in your ecological (economical) niche!
Unfortunately, we have only shifted the challenge with this short and simple solution. How to become the fittest in your niche? In this article we discuss the contribution of standardization as part of the answer, and we discuss the role of architects in standardization. We postulate a partial solution as:

- Employ skilled system architects.
- Apply an agile system architecting process.
- Determine the right subjects and moments for standardization.
- Apply a sensible standardization process.

The structure of this paper is that we will discuss respectively:

- Why

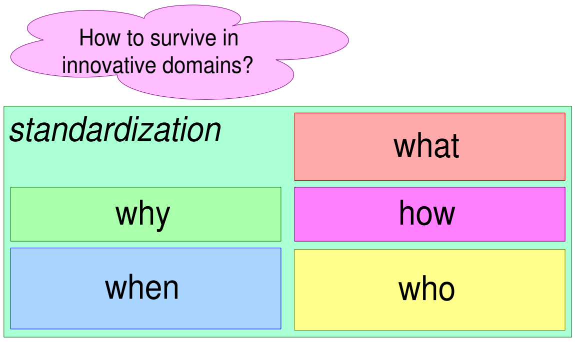

Figure 2: Figure Of Contents™

- When
- What
- How
- Who

of standardization, as also shown in Figure 2.

2 Why Standardization

The rationale of standardization depends on the viewpoint. Figure 3 shows four different viewpoints: *component*, *system*, *system of systems*, and *complementing systems*. We will take the position of system throughout this paper, but we should realize that *suppliers*, *customers* and *complementers* have their own specific interests in standardization.

Suppliers create and sell **components**. A system company needs to focus on its core business, hence it likes to standardize non-core components. If these standardized components become a commodity, then the system company benefits from cost reductions as well as ongoing innovations in these components.

System companies create and sell **systems**. Note that this whole hierarchy is recursive, a component builder perceives itself as system company. For example, the camera provider for an X-ray imaging chain, has component suppliers delivering lenses, CCD-chips et cetera.

Customers create a **system-of-systems** to address their needs. Many individual systems delivered by different *system companies* are integrated. One of

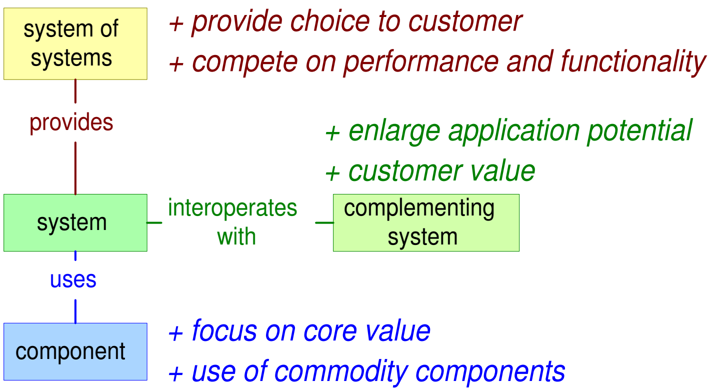

Figure 3: Classification of Standardization Tactics

the system companies is "our" company, the others are our *complementers*. Customers have a choice between competitors. Standardization of system interfaces adds value to customers by making systems interchangeable. As a consequence the competitive playground shifts to performance and functionality.

Complementors create and sell complementing **systems**. For example in the Catherization Laboratory the injection system, the monitoring system, and the cardiology information system are complementary to the X-ray system. Standardization of interfaces to complementers improves interoperability between these systems. Interoperability enlarges the space of potential application. Interoperability in itself and more applications provide more customer value.

A simple reference model to help in making *make or buy* decisions is based on *core*, *key*, and *base* technology, see figure 4.

Core technology is technology where the company is adding value. In order to be able to add value, this technology should be developed by the company itself.

Key technology is technology which is critical for the final system performance. If the system performance can not be reached by means of third party technology than the company must develop it themselves. Otherwise outsourcing or buying is attractive, in order to focus as much as possible on *core* technology added value. However when outsourcing or buying an intimate partnership is recommended to ensure the proper performance level.

Base technology is technology which is available on the market and where the development is driven by other systems or applications. Care should be taken

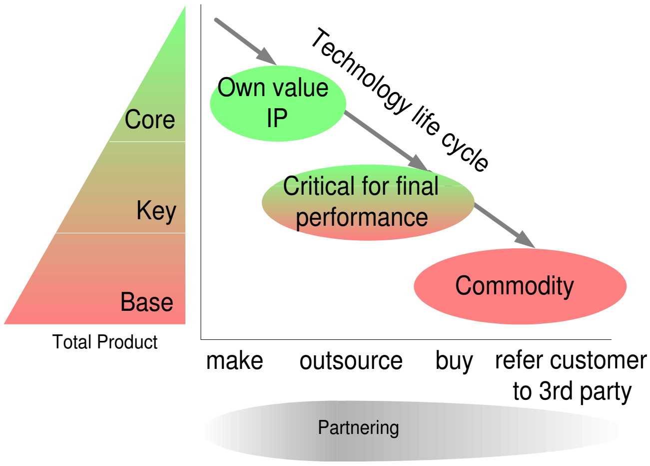

Figure 4: Focus on Core; not on Key or Base Technology?

that these external developments can be followed. Own developments here are de-focusing the attention from the company's core technology.

From the perspective of a *system* company there is a clear benefit to standardize interfaces to components in key and base technology areas. By such standardization the main focus of the company is on the core technology areas, where the company adds its specific value.

3 When to standardize?

A crucial question for standardization is *when to standardize*. Both standardization too early as well as too late can be rather damaging. Figure 5 shows characteristics and consequences of standardizing too early, at the right moment, and too late.

Too early standardization often results in *technological compromises*; The right level of standardization is not realistic technological causing compromises in the standard to make the realization feasible. In the early phases too little is known about the application of the standard, the *requirements are unknown*. The early standard is based on *insufficient and uncertain facts*, while the *intuition is not calibrated*. The value in young markets is based on responsiveness to market needs and differentiation. Standardization can unify competitive products, causing *loss of competitive edge*. The combination of these factors causes a *mismatch of expectations*: customer expect the availability of reliable and interoperable solutions, while the involved parties are in fact still learning what is needed and how to realize it.

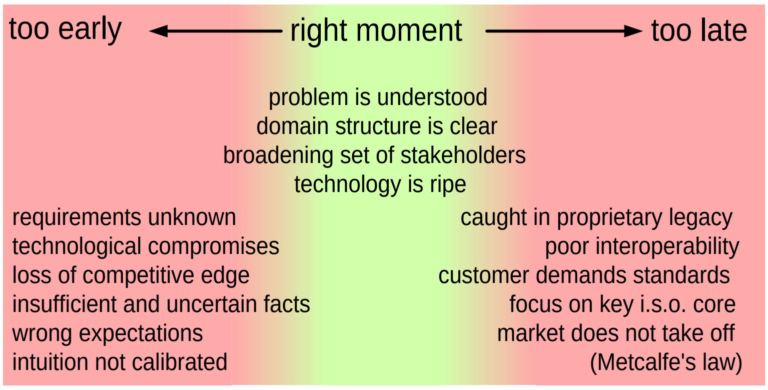

Figure 5: When to Standardize

At the right moment to standardize the *problem is understood* and the *domain structure is clear*. A *broadening set of stakeholders* will benefit from the standardization. The *technology is ripe*, such that implementations are feasible within acceptable time, cost and effort constraints.

Too late standardization causes a company to be*caught in proprietary legacy*. The products depend heavily on the original solution and the realization is so much intertwined that migration to standard solution is costly and painful. For the customers the consequence is often *poor interoperability*, causing *customers to demand standards*. The *focus of the company is on key technology instead of core technology*. Some standards have to be in place to create sufficient market, if the standard is late, then *the market does not take off*. This is related to Metcalfe's law: "Metcalfe's law states that the value of a telecommunications network is proportional to the square of the number of users of the system"[1] The value of a standard also increases more than proportional with the number of involved stakeholders.

Roadmapping is one of the tools to develop a strategic view on the business dynamics, see [1] for a more extensive description of roadmapping. In essence *roadmapping* is a technique where trends and developments are mapped and visualized as function of time. These trends are first of all external trends: what happens in the market (what are customer expectations and needs, what are domain specific trends in applications?), and what happens in technology (what are technological challenges, where are technological opportunities). With these inputs the strategic positioning of the company is translated in *products* (What products with what features and characteristics do we want to offer in the product portfolio). We need people and processes to realize these products and the technology used inside.

[1] source: wikipedia `http://en.wikipedia.org/wiki/Metcalfe's_law`.

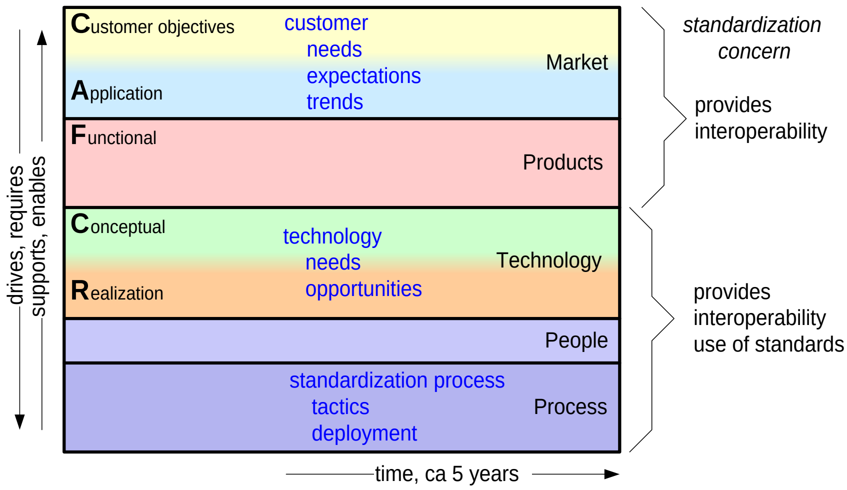

Figure 6: Roadmapping as Tool

Part of the processes will deal with the standardization itself, tactics as well as deployment. The standardization concern in the market and product roadmap is how to provide interoperability. The standardization concern in technology, people and process is two-sided: how to provide interoperability and how to harvest the use of standards.

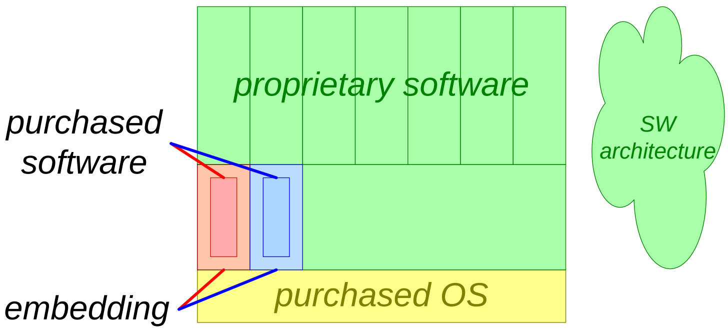

Figure 7: Purchased SW Requires Embedding

A complicating factor, from system creator perspective, is the use of COTS (Commercial Of The Shelf) software. Software developed as part of a platform follows the architecture guidelines of the platform. However, purchased software has been developed independent of the platform, using it's own architecture guidelines. This same complication may occur when software is purchased as part of a standardization effort. Figure 7 shows that purchased software requires some kind of embedding to fit it into the desired architecture.

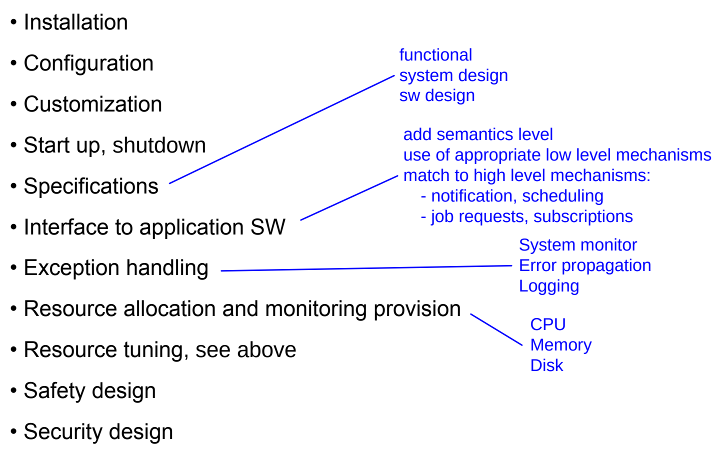

Figure 8: Embedding Costs of Purchased SW

Figure 8 zooms in on the typical additional efforts to embed purchased software in a platform. Most embedding effort is required to ensure the desired system level behavior and qualities: configuration, installation, start-up and shutdown et cetera.

Returning to the question *when to standardize*, we have to look at many considerations at the same time. Figure 9 shows a balance with pro and contra considerations for COTS. The figure is also annotated with the changes in time of these considerations. Some factors increase in weight (contra: integration effort, release propagation, required know how, and transition cost; pro: innovation from outside, focus on core technology, initial cost reduction, faster to market, interoperability, functional integration), some factors stay the same (flexibility, embedding), and some factors decrease in weight (license costs, performance, and resource use).

The *contra* factors that increase are mostly increasing due to the ever increasing size and complexity of systems. The *pro* factors are in-line with the formulated reasons for standardization. The benefits will outweigh the disadvantages, unless the transition costs have become too high. In that case a company is caught in the legacy trap.

Figure 10 shows a reference model for image handling functions. This reference model is classifying application areas on the basis of those characteristics that have a great impact on design decisions, such as the degree of distribution, the degree and the cause of variation and life-cycle. Such a reference model is one of the means to cope with widely different life-cycles.

Imaging and treatment functions are provided of modality systems with the focus on the patient. Safety plays an important role, in view of all kinds of hazards such as radiation, RF power, mechanical movements et cetera. The variation between systems is mostly determined by:

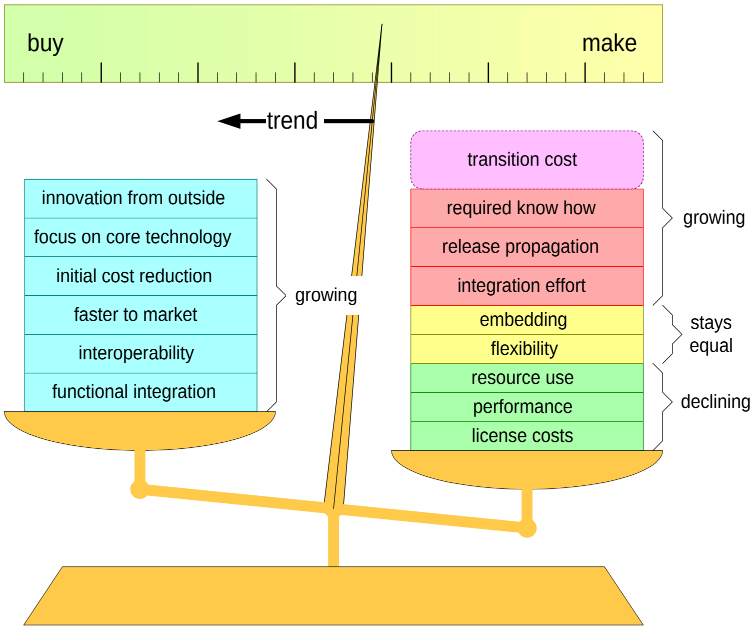

Figure 9: Balance of Considerations and Trends

- the acquisition technology and its underlying physics principles.
- the anatomy to be imaged
- the pathology to be imaged

The complexity of these systems is mostly in the combination of many technologies at state-of-the-art level.

Image handling functions (where the medical imaging workstation belongs) are distributed over the hospital, with work-spots where needed. The safety related hazards are much more indirect (identification, left-right exchange). The variation is more or less the same as the modality systems: acquisition physics, anatomy and pathology.

The *information handling* systems are entirely distributed, information needs to be accessible from everywhere. A wide variation in functionality is caused by "social-geographic" factors:

- psycho-social factors
- political factors
- cultural factors
- language factors

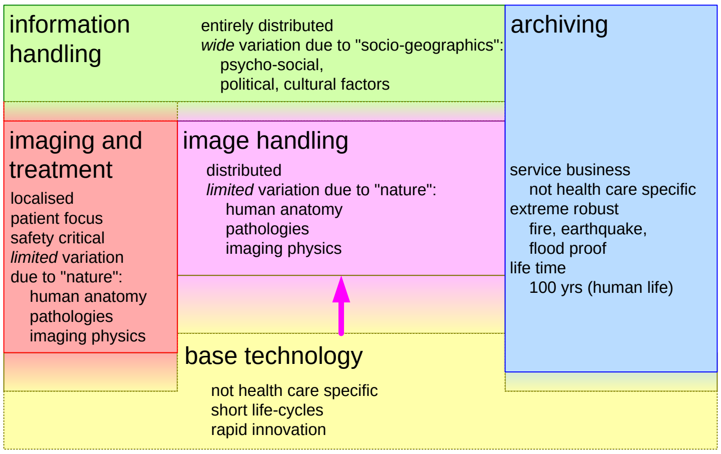

Figure 10: Reference model for health care automation

These factors influence what information must be stored (liability), or must not be stored (privacy), how information is to be presented and exchanged, who may access that information, et cetera.

The *archiving* of images and information in a robust and reliable way is a highly specialized activity. The storage of information in such a way that it survives fires, floods, and earthquakes is not trivial[2]. Specialized service providers offer this kind of storage, where the service is location-independent thanks to the high-bandwidth networks.

All of these application functions build on top of readily available IT components: the *base technology*. These IT components are innovated rapidly, resulting in short component life-cycles. Economic pressure from other domains stimulate the rapid innovation of these technologies. The amount of domain-specific technology that has to be developed is decreasing, and is replaced by base technology.

3.1 Example of standardization of health care information model

The health care industry is striving for interoperability by working on standard exchange formats and protocols. The driving force behind this standardization is the ACR/NEMA, in which equipment manufacturers participate in the standardization process.

Standardization and innovation are often opposing forces. The solution is often found in defining an extendable format. and in standardization of the mature functionality. Figure 11 shows the approach as followed by the medical imaging

[2]Today terrorist attacks need to be included in this list full of disasters, and secure needs to be added to the required qualities.

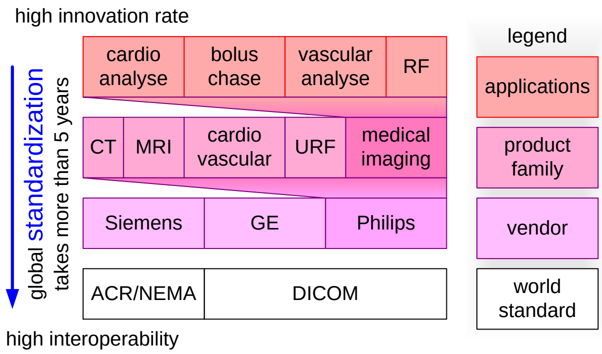

Figure 11: Information model, standardization for interoperability

product group within Philips around 1995. The communication infrastructure and the mature application information is standardized in DICOM. The, at that time, new auto-print functionality was standardized at vendor level. Further standardization of auto-print is pushed via participation in DICOM work groups.

A good strategy is to use the standard data formats as much as possible, and to build vendor specific extensions as long as the required functionality is not yet standardized. The tension between standardization and innovation is also present at many levels: between vendors, but also between product groups in the same company and also between applications within the same product. At all levels the same strategy is deployed. Product family specific extensions are made as long as no standard vendor solution is available.

This strategy serves both needs: interoperability for mature, well defined functionality and room for innovative exploration.

The information model used for import, export and storage on removable media is one of the most important interfaces of these systems. The functionality and the behavior of the system depend completely on the availability and correctness of this information. The specification of the information model and the level of adherence and the deviations is a significant part of the specification and the specification effort. A full time architect created and maintained this part of the specification.

The life cycle of standardization in this example from application specific feature to global standard took at least five years. This time constant is highly domain dependent. For example, in the optical disc storage this time constant is in the order of six to nine months.

4 What to standardize?

The next crucial question is *what* to standardize: implementations, designs, concepts, interfaces, or something else? We recommend that standards focus on interfaces at the **what** aspects, not the**how** aspects. Figure 12 shows that standards specify interfaces at black box level. A block box has functions with parameters in a given format. The black box shows desired behavior as specified in the protocol. The standard will also tell something about the characteristics of the black box, such as performance. Note that most characteristics depend strongly on the implementation. Nevertheless, users of the standard need to be able to reason about the characteristics. So a black box level description of characteristics is required.

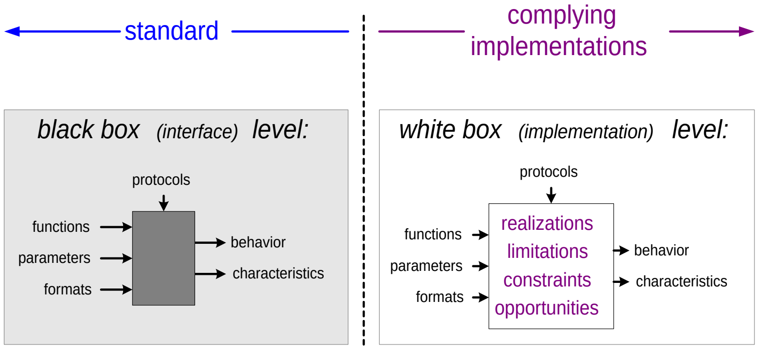

Figure 12: Standards describe **what**

Implementations may comply with the standard. A compliant implementation will behave according the standard, but the implementation itself adds specific limitations, constraints and opportunities.

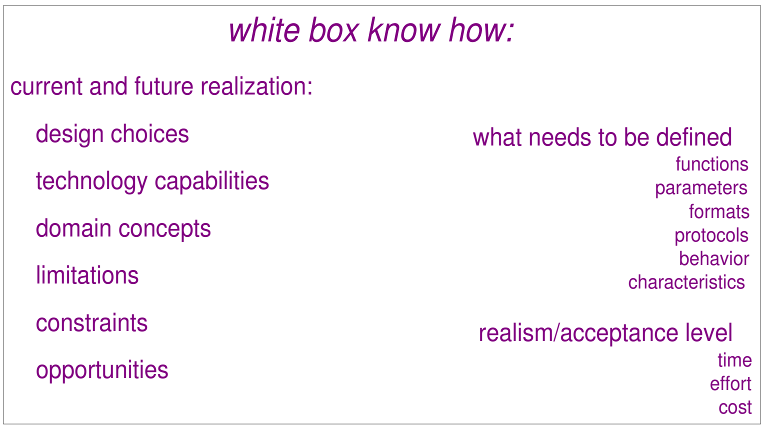

Figure 13: Input from implementation know how

When creating a standard know how is required of potential implementations, to ensure that the standard covers all relevant functions and parameters and to ensure that the standard is feasible in the envisioned time horizon. Examples of white box know how that is used during the standardization process is shown in Figure 13:

- design choices
- technology capabilities
- domain concepts
- limitations
- constraints
- opportunities

Besides this technological know how also the expectations of the standardization stakeholders are taken into account, such as time, effort and cost.

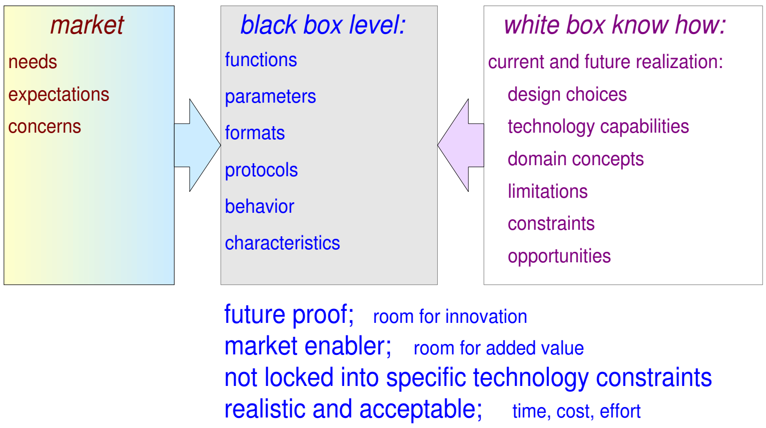

Figure 14: Towards a Standard

To create a standard we have to reason from external needs to technological constraints and opportunities. Figure 14 shows how the white box view is squeezed between Market needs, expectations and concerns, and white box know how. The creators of the standard will use the following criteria for the standardization product:

future proof room for innovation

market enabler room for added value

not locked into specific technology constraints

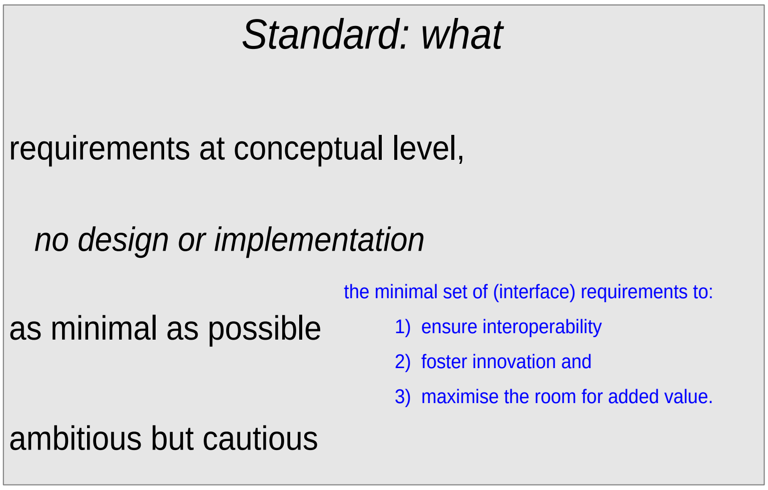

Figure 15: What Should be in a Standard

realistic and acceptable time, cost, effort

Figure 15 provides another look at *what* should be in a standard. Again the fact is emphasized that the standard should not enforce a specific implementation, but should be formulated at conceptual level. Also emphasized is the need to keep the standard as minimal as possible, only that should be in the standard to achieve its goals of interoperability and future innovative potential. It is a balancing act between ambition and caution.

In the section *When* we extensively discussed the cost of integration of third party components. One of the counter measures for such integration cost is to embed individual standards in a broader framework, a Reference Architecture, to ease integration, see Figure 16.

5 How to standardize

We propose a four phase standardization approach:

- explore
- analyze
- standardize
- deploy

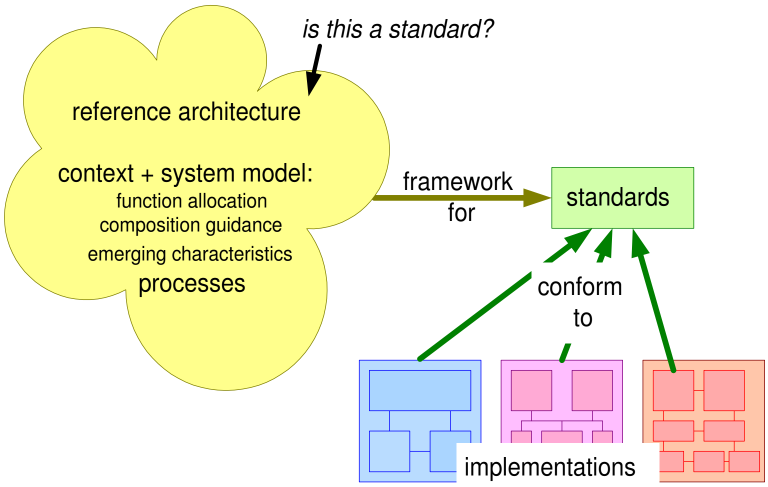

Figure 16: Embedding in a Reference Architecture

as shown in Figure 17.

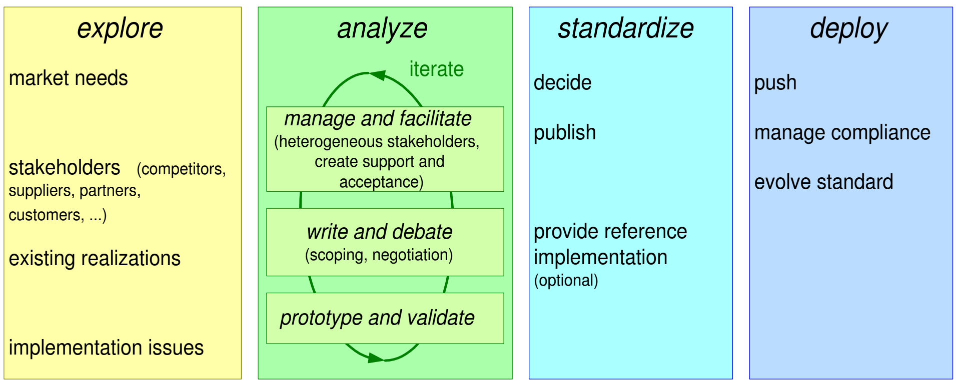

Figure 17: Flow of Standardization

In the *exploration* phase the *needs* in the market are inventoried, as well as the standardization *stakeholders*, such as competitors, complementors, suppliers, and customers. Also the *existing realizations* are analyzed to mine the, often implicit, know how, and to identify *implementation issues*.

During the analysis phase we iterate over prototyping and validation, writing and debating (scoping, negotiation), and managing and facilitating heterogeneous stakeholders to create support and acceptance.

The standardization phase includes making decisions and publishing documentation. A possible means to support the standardization process is the creation and release of a reference implementation that illustrates the standards and its concepts. A reference implementation helps other implementors with verification and it demonstrates feasibility.

The last phase is deployment, where the use is pushed. The challenge is to manage compliance in this hectic phase. The consequence of using a standard is that new needs are created and unforeseen issues surface, the newly introduced standard will need to *evolve*.

6 Who is involved, role of the architect

The business process for an organization that creates and builds systems consisting of hardware and software is decomposed in four main processes as shown in figure 18.

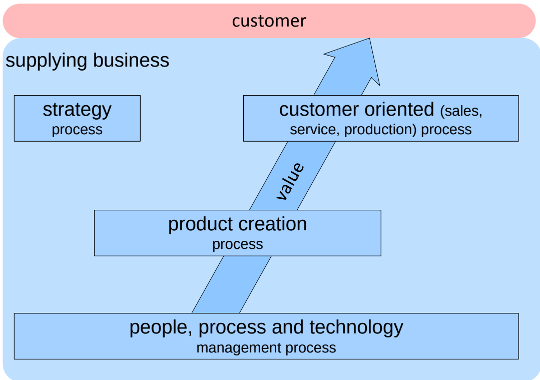

Figure 18: Simplified decomposition of the business in 4 main processes

The decomposition in 4 main processes leaves out all connecting supporting and other processes. The function of the 4 main processes is:

Customer Oriented Process This process performs in repetitive mode all direct interaction with the customer. This primary process is the cash-flow generating part of the enterprise. All other processes only spend money.

Product Creation Process This Process feeds the Customer Oriented Process with new products. This process ensures the continuity of the enterprise by creating products which enables the primary process to generate cash-flow tomorrow as well.

People and Technology Management Process Here the main assets of the company are managed: the know how and skills residing in people.

Strategy Process This process is future oriented, not constrained by short term goals, it is defining the future direction of the company by means of roadmaps. These roadmaps give direction to the Product Creation Process and the People and Technology Management Process. For the medium term these roadmaps are transformed in budgets and plans, which are committal for all stakeholders.

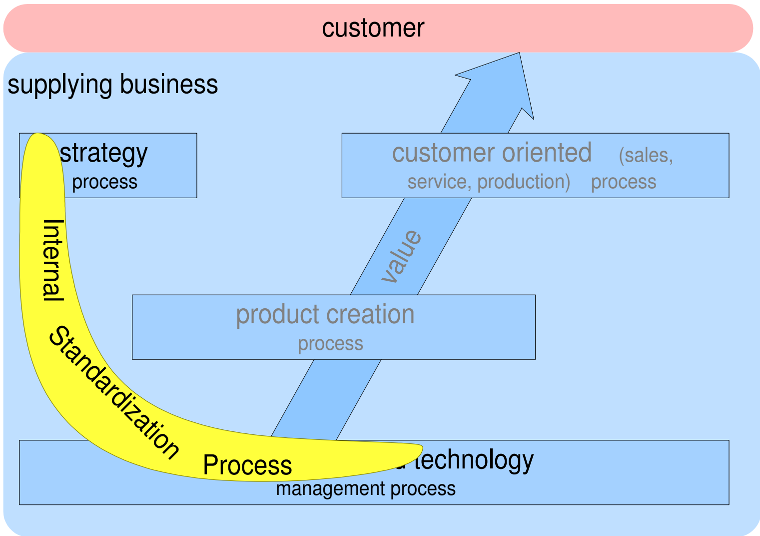

Figure 19: Internal Standardization Process == Highly Strategic!

In Figure 19 the standardization process is overlayed on top of the original process decomposition. Standardization is a highly strategic activity that connects the *Strategy Process* with the *People and Technology Management Process*.

The standardization activity is much more than only a technical balancing act. Figure 20 shows many non-technical aspects of standardization:

legal, IP oriented How to arrange licenses, patents, copyright?

political Who has decision power, who is in control, what are (hidden) interests, what coalitions are created, what networks are involved?

business What are involved value chains, what are the expected business models, what are the foreseen market developments? Note the relation with legal and hence political aspects.

social Are there sensitive issues, such as privacy? What is the social value or impact of the standard?

The broad and strategic nature of standardization indicates that architects should play a significant role in the standardization. Nevertheless, the relationship between architects and standardization processes is characterized by a few strong opposing feelings: The benefits that the architect can focus on the core, without worrying

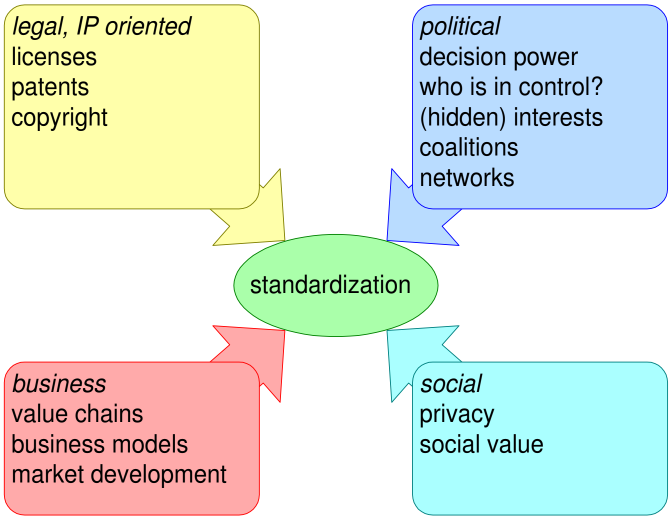

Figure 20: Non technical aspects of standardization

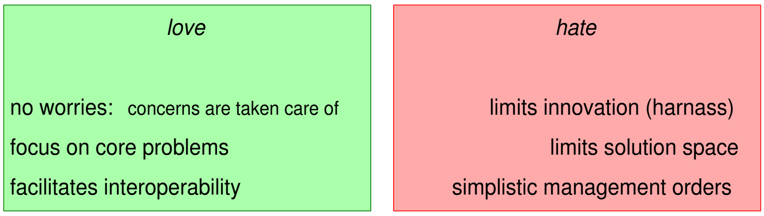

Figure 21: Architect and Standards: Love-Hate Relationship

about peripheral concerns is clearly attractive. Standardization allows the architects to compose, where the standards facilitates the interoperability. However, standards may also be felt as over-constraining, a harness, limiting the innovation. Standard also reduce the solution space, often a desired effect, but it might turn into such an over-constraint. Architects really hate naive and oversimplified management orders to standardize; for example, replace this well designed proprietary, problem specific, web-server by this standard general purpose web-server, while the architects can predict the performance disasters caused by such a transition.

Architects have a rare combination of creativity and lateral thinking, where standardization requires more rigorous discipline and a surge for consistence close to dogmatism. As a consequence standardization needs to be teamwork, where architects are involved because of their know how and broad reasoning, but also involving standardization oriented people.

7 Conclusion

We started with the question: “How to survive in innovative domains”? Figure 22 reiterates the standardization oriented part of our theses:

- Determine the right subjects and moments for standardization.
- Apply a sensible standardization process.

We explored the why, when, what, how, and who of standardization to explore the thesis that a combination of architecting and standardization is part of the answer to this challenge.

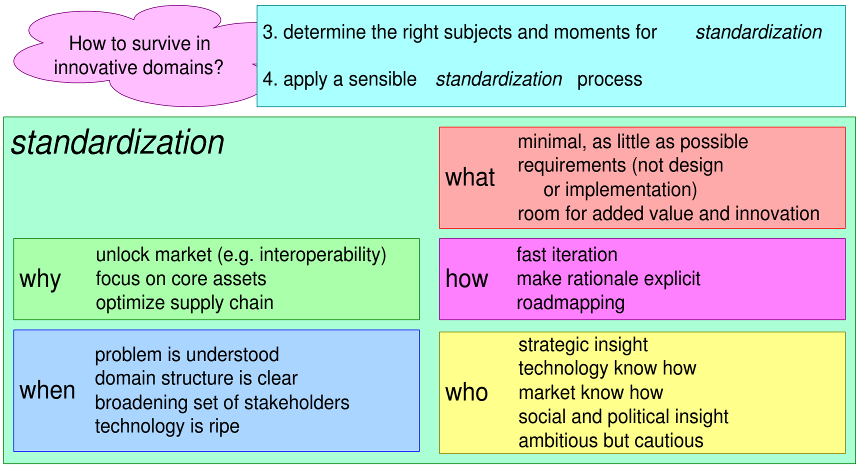

Figure 22: Conclusions

Our conclusion is that a standardization approach where the balancing act is performed by mature architects definitely helps to survive in innovative domains. The consequence is that companies should endorse and support standardization is a highly strategic process, with sufficient management support and rewards.

8 Acknowledgements

ECMA international supported the creation of this presentation and article. Onno Elzinga provided input and feedback.

References

[1] Gerrit Muller. Roadmapping. http://www.gaudisite.nl/RoadmappingPaper.pdf, 1999.

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

History

Version: 1.0, date: September 24, 2007 changed by: Gerrit Muller

- created when, what, how, who text
- changed status to draft

Version: 0.6, date: September 20, 2007 changed by: Gerrit Muller

- updated what slides
- created paper skeleton
- created why text

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- added "What" slides
- removed Architecting slides

Version: 0.4, date: August 13, 2007 changed by: Gerrit Muller

- extended conclusion diagram
- added navigation slides

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- Improved visualizations of figures
- added more background on architecting

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- added many figures

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- Created, no changelog yet