Innovation, Disruptive Change, and Architecting.

White Paper Resulting from Architecture Forum Meeting

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1. Introduction

Architects should deal with disruptive change and should facilitate innovation. In practice neither goal is easily achieved. Anticipation of disruptive change is nearly a contradiction in terms. Innovation and risk reduction create a lot of mutual tensions. This forum discussed the following questions:

- How does architecture catalyze/enable innovation?
- How does architecture stifle innovation?
- What is the impact of disruptive change on architecture?
- How to cope with disruptive change?

The area of disruptive technologies and disruptive innovation is extensively described by Christensen, starting in the article [Bowen 1995] and followed by the books [Christensen 1997] and [Christensen 2003]. A good introduction can be found at http://en.wikipedia.org/wiki/Disruptive_technology.

2. Disruptive versus incremental change

Most product changes take place in an evolutionary fashion, where many small incremental changes successively move the products forward. Most companies and architects are used to this incremental change model. Incremental change coincides with identifiable and manageable risks. Most experienced managers and architects have learned that large changes relate to large risks, and that large risks often cause large problems, such as cost over runs, delays and ill-performing solutions. Experience tends to make product creators more conservative.

Christensen [1997] also points out that business that are well established in their industry also tend to stick to doing what they have always done, with improved performance and efficiency. There is an internal inertia that prohibits “risky” experimentation with product attributes and business models.

However, what happens when no incremental change is available that achieves the desired performance and functionality level? Or what happens when a new entrant to the industry or

technology changes the game? Following the conservative path means that the product performance stays saturated near the maximum performance level related to the current solution paradigm. Only disruptive changes facilitate the progress to new levels of performance.

3. The FAA NextGen case

An example of saturation of the performance level is the National Airspace System (NAS), managed by the FAA, see

http://www.faa.gov/about/office_org/headquarters_offices/ato/publications/nextgenplan/nextgenvision/. The current NAS follows and controls every plane individually. When the airplanes are capable of predicting, communicating, and maintaining agreed-upon trajectory, and of maintaining separation of other aircraft, then the capacity of the total NAS can be increased significantly. This change moves the NAS into a completely new paradigm.

In this case the driver of the change is the anticipation that the amount of air traffic will continue to increase, while today's system is already at an utilization level where small disruptions cause an avalanche of delays and cancellations. The whole system of airlines, airports, flight-crews, air traffic controllers, et cetera is tremendously complex and interdependent. Cancellation of a single flight causes the shortage of one plane and one crew at the receiving airport, which propagates throughout the schedule.

The total air transportation system has a major economic contribution with many heterogeneous contributors. These contributors may have totally different interests. For example, private pilots own a huge fleet of small airplanes, with all kinds of (legacy) equipment and hence capabilities. At the other hand, commercial airlines contribute most in terms of passenger-miles and economy. Not all commercial airlines endorse higher capacity of the air space, despite the economical value for them, because it might also cause new competitive threats.

Note that the air transportation system is extremely conservative and has to maintain a high safety standard.

The transition to this new paradigm is architected and orchestrated by the FAA. They have set up a long term (decades) broad program involving all stakeholders from early on. The main enforcing power for the FAA is the financial budget. From this observation we derive the following principle:

Principle 6.1 *In very large heterogeneous projects money is the unifying metric for decision making.*

In practice also the reversal can often be observed: *Architectures bend around the money.*

The NextGen case also illustrates the challenge of orchestrating a transition to a new, disruptive architecture and a corresponding operational paradigm for a large, complex system that has to remain operational 24/7 while maintaining the levels of safety and reliability required. In addition to its technical attributes, the new architecture also has to accommodate this elongated transition where the new and old architecture will live side by side.

4. Innovation, large companies and architecting

Large companies tend to struggle with their innovation capabilities [Christensen 1997]. Small companies tend to be more agile and, due to their size, have less specialized functions and roles. For example, in small companies the architecting role is implicitly performed by few people also performing other jobs. The specialization into system architects and system engineers is typically happening at larger companies counteracting the specialization into technological experts.

One of the main contributions of system architects and engineers is the synthesis of the system, the integration of many mono-disciplinary solutions into a working system. The perceived value of this role is risk mitigation; Lack of systems architecting in early project phases tend to cause integration problems later in the project. Organizations have the tendency to emphasize the risk mitigation part of the system architecting role. The consequence is that architects tend to become conservative.

The same observations can be made for the processes within large companies. Small companies have limited and agile processes, while large companies have more

institutionalized and rigid processes. While repeating sufficiently similar projects, these rigid processes support the projects; Previous experience is re-used in succeeding projects, preventing repetition of previous mistakes. Unfortunately, the same more rigid processes turn into a constraint when the circumstances are significantly different.

Many large companies have institutionalized product creation, business creation, architecture management, and even innovation. The question is: *Can innovation be captured in a process?* Most members of the Architecting Forum are part of larger companies, such as Raytheon, Philips and Nokia. These companies have reached the size where the innovation capability has become a top management concern. All these companies have developed initiatives to increase the innovation capability. Philips, for example, promotes *open innovation* where frequent interaction with third parties such as universities and research institutes is stimulated.

Google, famously, has followed an approach where innovation is embedded into the job description [Iyer 2008]. Employees are expected to spend 80% of their time on the core search business according to their (very specific) job description. The remaining 20% are to be spent on technical projects of their own free choosing. Over a given 6 month period these 20% projects resulted accounted for more than half of new products and features.

Wikinomics [Tapscott 2006] describes how an increasing number of companies are utilizing open source and crowd sourcing principles to augment their innovation capability. This comes from the realization that "idea potential" outside the walls of the company are infinitely larger than within.

5. The Raytheon Innovation Program Case

Within large companies many employees have potentially innovative ideas. Unfortunately, the processes and the (risk-avoidance) culture tend to stifle the nurturing and propagation of these ideas. The assertion is that employees are as innovative as their colleagues in smaller companies, but that the context is much less stimulating in large companies.

Based on this assertion a corporate level program was started within Raytheon to detect, nurture and eventually propagate ideas through the organization. A small group of people in

the office of innovation facilitate this process, from the elicitation of ideas until the allocation to resources to deploy the idea. Core to the program is that the initiators of the idea keep ownership of their idea *and there is no corporate filtering – ideas are nurtured to the point they are adopted by business units or the originator determines it is time to shelve the idea*. The facilitation helps them to find complementary resources to nurture and propagate the idea further.

One of the tricky parts of these initiatives *is not having "experts" filter ideas, because truly disruptive ideas are often viewed as impractical or of non value initially. Thus the innovation system is architected to find connect points of champions, peer evaluation groups, and potential sponsors as the idea is developed. This gives time for disruptive ideas to be shaped into valuable business propositions*. Selection processes tend to *average* ideas, which is a risk for the more exceptional ideas.

6. The relationship between processes, innovation and disruptive changes

Large companies tend to guide or control the creation of processes with a multitude of processes: *New business development*, *architecture management*, *product line or product family management*, *platform development*, *vision and mission definition*, *roadmapping*, *business reviews*, et cetera. The MATI group (Management of Accelerated Technology Innovation), http://mati.ncms.org/whatismati.htm, has made a map of all related processes.

Many of these processes play at enterprise or business level, where architecture is only one of the elements. Many processes attempt to anticipate future needs and changes. For architecture this translates into: How much can we anticipate future needs and changes? It is clearly an architect's responsibility to balance the tensions between:

- Short term activities
- Anticipating future needs and changes
- Coping with the unforeseen

Focusing on *short term activities*, and ignoring future needs and changes is often a poor solution. Few infrastructural provisions can make or break the realization of future needs and

changes. If the original architecture does not provide these few provisions it might be painful to add these later, with all related legacy and life cycle problems.

Creating an architecture where all *future needs and changes are anticipated* is in general a poor solution. The architecture gets heavy and extensive, due to all future provisions. While later, when the actual changes or needs get actual, we often discover new aspects that were not anticipated.

To *cope with the unforeseen* we often need the least complex architecture. More simple architectures can more easily be changed than more complex architectures. Note that making provisions to anticipate often makes the architecture more complex. In other words there is a clear tension between anticipation and coping with the unforeseen! Some could argue that at the current pace of innovation in many industries you run the risk of your competitor innovating in "circles around you" while you spend time and resources anticipating. Therefore organizations may be well advised to hone their architectural agility and ability to cope with the unforeseen.

This architectural balancing act is embedded in the broader enterprise and business processes that have to perform exactly the same balancing act with an even broader set of concerns. One of the main challenges for architects is to get sufficient attention at business level for technology innovation[1], or vice versa the business management team has the challenge to balance heterogeneous aspects from markets, applications, business models, et cetera with technology aspects.

The field of innovation can be decomposed further, for example:

- Do we innovate for existing users/markets or for new users/markets?
- Do we innovate ourselves, or do we harvest innovations by others?

[1] Note that architects have the same challenge to get sufficient attention for technology "maintenance" or renovation, i.e. the less disruptive changes in technology.

The tens of processes that are defined to guide the business into the future deal with all these different options. The main tension in all these processes is the tension between anticipation and unforeseeable innovations.

7. The time dimension

Time plays a dominant role in innovation and disruptive changes. When will some disruptive technology bypass the existing technology? When is the market ripe for new types of applications? The FAA case is an example with a long time horizon. The time to switch to the new flight control paradigm is needed to propagate all required changes throughout the broad mass of stakeholders and the related systems.

Other industries, for example automotive, are also used to planning horizons of many years. The design of one generation of cars with its related platform, plus the time needed to develop the entire supply chain, plus the time needed for qualification add up to many years. The automotive industry still struggles to adapt easily to the "lifecycle gap" between low frequency vehicle cycles and high frequency consumer electronic cycles. Architecture mechanisms (using standardized interface technologies like,e.g., BlueTooth, or instances of an adapter pattern) play a key role to mitigate these cycle incompatibilities. The processes in this industry allow some classes of innovation related to electronic features to be introduced relatively late in the process of creating a new generation. There is a window of opportunity where innovative functions or features that are ripe enough can be inserted in the ongoing development.

This automotive example shows that innovation and regular product development are not exclusive, but can be combined to a certain degree. The architecture plays here a facilitating role. Inserting innovative features works well if they fit within the architecture.

A company like Google on the other hand follows a “throw it out there and see what sticks” approach. They simply expose the outcomes of the many individual and small team “20% projects” to their users, and use their own analytical tools to analyze their acceptance (see e.g. http://labs.google.com/). They have an explicitly stated tolerance (and even encouragement) for failure.

8. Summary and Conclusions

We started with four questions. We will repeat the questions with a summary of the answers that we hit during the discussion

1. How does architecture catalyze/enable innovation?

Less complex architectures adapt more easily to new needs and changes. Some critical architectural decisions can make or break future changes and can facilitate insertion of future changes.

2. How does architecture stifle innovation?

More complex architectures are costly to adapt, potentially stifling innovation.

3. What is the impact of disruptive change on architecture?

The main question here is if the disruptive change was foreseeable and has been anticipated. Unforeseeable disruptive changes may disrupt the architecture. Again more simple architectures will adapt more easily than complex architectures.

4. How to cope with disruptive change?

We extensively discussed the embedding of architecting in business and enterprise processes. Large companies tend to have many processes with intend to *control* or *manage* change. For innovation and disruptive change a different mindset might be beneficial: being agile by accepting that not everything can be foreseen and hence not everything can be controlled or managed. Note that the same consideration also holds for architecting. A key question is how can an organization hone its “architectural agility”?

Acknowledgements

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