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Topic (iii): Architecture

EVALUATING ARCHITECTURAL OPTIONS: ONS EXPERIENCE OF CONDUCTING ARCHITECTURE REVIEWS

Supporting Paper

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I. INTRODUCTION

1. Changes to business systems, or the development of new business systems, involve the evaluation of alternative solutions, typically in the Feasibility phase of a project. Determining which of several possible solution options is the most suitable for implementation is a complex yet critical task. Selecting the wrong architecture can prove an expensive mistake, resulting in a solution that is not fit for purpose.

2. The Office for National Statistics (ONS) has developed an architecture review method, based broadly on the Architecture Trade-off Analysis Method (ATAM) from Carnegie Mellon University (Kazman et al. 2000), and has gained several years' experience of applying it during the project lifecycle. This paper describes the method, and the ONS experience of its use.

II. BACKGROUND

A. The case for architecture reviews

3. At ONS, business change projects are led by business management. This rightly ensures that business drivers are at the forefront of project decisions, but it does carry the risk that significant requirements that do not relate to end-user functionality will receive insufficient attention. These requirements are often known as "Non-function Requirements" (NFRs) (wikipedia.org 2009), and a failure to consider them early enough in the development life-cycle can lead to the adoption of solutions with an inappropriate architecture. This may lead to a solution that lacks critical characteristics, such as security, modifiability, performance, reliability. These characteristics are commonly known as Quality Attributes, and are discussed in more detail in Section B below.

4. The ONS development life-cycle contains an early phase known as "Solution Shaping". This is the phase of the project where solutions options are explored alongside the articulation of prioritised business requirements. The key roles involved at this stage of a project are the business sponsors and users, the business analyst and the solution architect. A key deliverable at the end of this stage is the Feasibility Report, and it leads to a major project Gateway which determines whether a suitable business case has been made for the project to proceed, following the development of more detailed costs and benefits. It is towards the end of this phase that the ONS Architecture Review takes place - before the Feasibility Report has been written, but after the solution options have been explored and the main business requirements are understood.

5. The purpose of the Architecture Review is threefold:

a) To ensure at an early stage that the project is considering all requirements, including NFRs;
b) To fully understand the strengths and weaknesses of each solution option in relation to those requirements prior to deciding which solution option should be recommended for adoption;
c) To ensure that strategic aims and corporate architectural principles are considered as part of the process to select a preferred solution option.

B. ATAM and Quality Attributes

6. The IEEE Standard for a Software Quality Metrics Methodology describes software quality as "the degree to which software possesses a desired combination of attributes (e.g. reliability, interoperability)" (Software Engineering Standards Committee of the IEEE Computer Society 1998, p.iii).

7. In "Quality Attributes" (Barbacci et al. 1995), a technical report from the Software Engineering Institute at Carnegie Mellon University, the authors introduce a generic taxonomy of software quality attributes. Examples of Quality Attributes include performance, availability, reliability, functionality, usability, security, modifiability, portability, reusability, integrability, testability, variability, subsetability, conceptual integrity and buildability.

8. In "ATAM: Method for Architecture Evaluation" (Kazman et al. 2000), commissioned from the Software Engineering Institute by US Department of Defense, the authors describe an attribute-based method for evaluating software architectures which involves analysing the trade-off between quality attributes offered by different possible software architectures. It is beyond the scope of this paper to compare this method with other methods such as ARID (Clements 2000) and SAAM (Kazman et al. 1994), but those interested in reading more on the topic are invited to read "Evaluating Software Architectures" (Clements et al. 2001).

9. The underlying concepts in ATAM are highly attractive - a method to explore alternative solutions from the multi-dimensional perspective of quality attributes. In addition, the method engages the involvement of all key stakeholders: business sponsors, users, designers and developers. However, early ONS experience with applying ATAM in project reviews was less than satisfactory. The method involves the development of utility trees and the complexity of these trees combined with the relatively abstract nature of the Quality Attributes resulted in review meetings that struggled to retain the engagement of business stakeholders. As a result, ONS decided to adapt the method to suit its own needs.

III. THE ONS ARCHITECTURE REVIEW METHOD

C. The review process

10. An ONS Architecture Review is a collaborative effort, involving a team of stakeholders and knowledgeable peers. The team typically includes the solution owner, users, solution developers, the solution service provider and architects. The review centres on the completion of three matrices, which are described in more detail in Sections D, G and H below, respectively.

11. There are four phases to the process:

a) Completion of Matrix 1
b) Workshop Preparation
c) The Review Workshop
d) Completion of the Review Report

D. Matrix 1 - Business Requirements against Quality Attributes

	Architectural Design Goals				
Business Requirements	**Functionality**	**Performance**	**Availability**	**Subset-ability**	**Security**
1. Creating Templates					
1.1 To create Templates for publishable tables - comprising a combination of fixed text and variables.	✓✓	✓		✓✓	
1.2 To allow Table Templates to be created in four basic formats: Column, Row and Matrix (Must) and Triangle (Should).	✓✓			✓✓	
1.3 Any given Template can contain data from any Time Series dataset in CORD.	✓✓			✓✓	
1.4 To group together Templates and share global setting across the group.	✓✓			✓✓	
1.5 To allow the Template editor to override global settings.	✓✓			✓✓	✓
1.6 To allow access to Templates to be controlled – individuals can have Update permission, Read-only permission or no access to any given Template.	✓✓			✓✓	✓
1.7 To allow Templates to be copied e.g. to use as the basis for a new Template.	✓✓			✓✓	✓
1.8 To provide configuration management for Templates i.e. create a new version when a Template is changed and record who made the change and when.	✓✓			✓✓	✓
1.9 To allow certain Users to specify global settings (i.e House Style). These will be different users to Template Editors. Template Editors cannot change House Style.	✓✓			✓✓	✓
2. Render Table					
2.1 To select a subset (or all) of Templates within a Group and to render the tables with a single press of a button. (The most important requirement is for this to be quick and easy.)	✓✓	✓		✓✓	
2.2 To allow Mode, Status and Date to be specified as Run Time parameters.	✓✓	✓		✓✓	
2.3 Data should be retrieved from CORD at the time of Render. And should reflect the current data in CORD	✓✓	✓	✓	✓✓	✓
2.4 Retrieve data from CORD within 60 seconds.		✓✓			
2.5 Output formats must include pdf and html.	✓✓	✓	✓	✓✓	
3. Other					
3.1 Windows based functionality e.g. drag and drop, Undo, Print Preview.	✓✓	✓	✓	✓✓	
3.2 To access the application remotely e.g. teleworkers from home.	✓	✓✓	✓✓	✓✓	✓✓
Use of system should not affect CORD performance unduly.		✓✓	✓✓		

Figure 1 - Example Matrix 1

12. This Matrix represents a key simplification of the ATAM process. At ONS, we found that Quality Attributes were often too abstract to form the basis for intense discussion throughout a review. We decided therefore to focus on business requirements, which are expressed in language well understood by all stakeholders, including the solution owner and users. However, this switch from Quality Attribute to business requirements runs a risk that critical Non-Functional Requirements will be ignored. The purpose of

Matrix 1 is to cross-check the prioritised business requirements against those Quality Attributes that are considered the most important by the lead architect.

13. It can be completed as soon as the business requirements have been identified, and it acts as a check to ensure that the requirements reflect both functional and non-functional requirements. It does not require all stakeholders to be involved in its completion, but it may lead to the identification of additional business requirements that have not yet been documented. An example of this Matrix 1 is given in Figure 1 above.

E. Workshop preparation

14. A workshop has an appointed chair, who will lead the discussion during the Review Workshop, and will also typically take responsibility for completing the report. At ONS, a workshop can involve between 12 and 18 stakeholders for the best part of a whole day, so it is important that both logistics and relevant papers or presentation material and the spreadsheet containing the Matrices are prepared in advance.

F. The Review Workshop

15. The duration of the review workshop will depend on the size and complexity of the project under consideration. Quick reviews involving a small group of stakeholders can be accomplished in a few hours, but most ONS Architecture Reviews last the best part of a whole business day.

16. The Workshop agenda is typically as follows:

a) Introductions
b) Describe the business problem
c) Outline the solution options
d) Review Matrix 1
e) Populate Matrices 2 and 3

17. It is important to allocate sufficient time for the description of the business problem and solution options, since it is vital that all stakeholders have a good understanding of the differences between these. Whilst these will be drawn out during the completion of Matrices 2 and 3, spending more time ensuring a good understanding of each option will facilitate a more speedy completion of the matrices. As a general guide, at least half the time allocated to the review is likely to be spent describing and discussing the business problem and solution options.

18. Throughout the workshop, lists are updated on the walls of the room, identifying issues, risks, mitigations and actions. It is often the insights that lead to items being placed on these lists that are of the greatest value during the review workshop.

G. Matrix 2 - Examining risk trade-offs

18. This Matrix (an example of which is given in Figure 2 below) is the heart of the review, where the different trade-offs of the competing solution approaches are made explicit and can be compared and discussed. The Matrix contains a column for each Solution Option, and a row for each business requirement. Each cell is discussed by the review team, working across each row in turn. The content of each cell, which is agreed by the review team following discussion, is a measure of the risk of failure to achieve a given business requirement with that particular solution approach, and the consequential business impact of such a failure.

Business Requirements		Solution Option 1	Solution Option 2	Solution Option 3	Business Impact
To create Templates for publishable tables - comprising a combination of fixed text and variables for 2009+.	Likelihood:	1	2	3	
		6	12	18	6
To allow Table Templates to be created in four basic formats: Column, Row and Matrix (Must) and Triangle (Should).	Likelihood:	2	2	2	
		12	12	12	6
Any given Template can contain data from more than 1 Time Series dataset(s)6 in CORD.	Likelihood:	1	1	1	
		4	4	4	4
To group together Templates and share global setting across the group.	Likelihood:	1	3	1	
		4	12	4	4
To allow access to Templates to be controlled – individuals can have Update permission, Read-only permission or no access to any given Template.	Likelihood:	1	1	1	
		2	2	2	2
To allow Templates to be copied e.g. to use as the basis for a new Template.	Likelihood:	1	1	1	
		3	3	3	3
To provide configuration management for Templates i.e. create a new version when a Template is changed and record who made the change and when.	Likelihood:	2	5	2	
		4	10	4	2
To allow certain Users to specify global settings (i.e House Style). These will be different users to Template Editors. Template Editors cannot change House Style.	Likelihood:	2	5	1	
		4	10	2	2
To select a subset (or all) of Templates within a Group and to render the tables with a single press of a button. (The most important requirement is for	Likelihood:	1	2	1	
		3	6	3	3
To allow Mode, Status and Date to be specified as Run Time parameters	Likelihood:	1	1	1	
		6	6	6	6
Data should be retrieved from CORD at the time of Render. And should reflect the current data in CORD.	Likelihood:	1	1	1	
		6	6	6	6
Provide authorised users only with data.	Likelihood:	1	1	1	
		6	6	6	6
Retrieve data from CORD within 60 seconds.	Likelihood:	2	3	2	
		4	6	4	2
Output formats must include pdf and html.	Likelihood:	1	1	1	
		4	4	4	4
Windows based functionality e.g. drag and drop, Undo, Print Preview.	Likelihood:	2	4	4	
		4	8	8	2
To access the application remotely e.g. teleworkers from home.	Likelihood:	1	1	1	
		2	2	2	2
Use of system should not affect CORD performance unduly.	Likelihood:	3	3	3	
		12	12	12	4
Total:		86	121	100	

Figure 2 - Example Matrix 2

19. This Matrix represents another change by ONS from the ATAM approach. Our experience was that utility trees were complex, whereas ONS already had a well understood corporate risk method that scored risks according to their impact (on a scale of 1 to 6) and likelihood (on a scale of 1 to 5), with exposure being the product of the two numbers. The risk measure was therefore seen as an inverse of utility - one that was well understood by most stakeholders at ONS, and perhaps a perspective particularly well suited to the risk averse culture of a National Statistical Institute.

20. In most cases, the impact of failing to achieve a business requirement will be the same for each solution approach, so this can be agreed by the team for a whole row of the matrix before the team goes on to discuss the likelihood associated with each solution approach for that business requirement.

21. The ONS risk method produces an exposure score for each risk which is translated into a colour coded risk scale: Low Risk is coloured Yellow, Moderate Risk is Orange, High Risk is Red and Corporate Risk is Black. The colour coding has been built into the spreadsheet used at ONS, and it really helps the team look across the competing solution approaches and see the trade-offs being made between the different business requirements.

22. Whilst a total score is produced for each solution option, the lowest representing the lowest aggregate risk, care must be taken before reaching the conclusion that the lowest scoring option represents the preferred option. The matrix does not reflect the relative importance of the different business requirements, and so the process of completing the matrix should be seen as an aid to discussion, ensuring that all perspectives are considered, rather than a direct means to a decision.

23. It is often the case that the most valuable outcome from the process of completing the matrix is not the matrix itself, but the list of issues, actions and mitigations that are identified and noted during the lengthy discussion. Also of value is the generation of consensus among the team of what the risks really are, and which requirements are the most important. It helps give the team a common view of their project and its solution which helps to draw the team together before they move on to the design and construction phases of the project.

H. Matrix 3 - Assessing Architectural Fit

24. As part of its adoption of TOGAF (The Open Group Architecture Framework) (The Open Group 2009), ONS has developed a set of twenty Architecture Guiding Principles. These are clustered around five high-level principles:

a) Reusability
b) Integrability
c) Serviceability
d) Corporate Asset
e) Security

25. Matrix 3 (an example of which is given in Figure 3 below) involves assessing the extent to which each solution option satisfies a selected set of principles. In preparing for the workshop, the chair of the review will work with the lead architect to select at least two principles for each of the high-level principles. These then form the rows of the matrix, with the competing solution approaches again forming the columns. Each cell is discussed in turn, leading to a number that represents the extent to which that particular solution satisfies the given principle.

26. As with Matrix 2, a total score is calculated (a higher score representing a better architectural fit), but care must be taken when drawing a conclusion on the basis of the total alone. It is often more instructive to examine how many, and which, principles each solution option falls short of satisfying.

Architecture Principles	Solution Option 1	Solution Option 2	Solution Option 3
Reusability			
GP 1. Always consider reuse	5	3	3
GP16: User access through consistent and easy to use interfaces from all appropriate locations	3	3	5
Integrability			
GP8: Develop Flexible Solutions	7	5	5
GP19: Reduce integration complexity	3	3	5
Serviceability			
GP2: Control Technical Diversity	3	3	3
GP6: Architecture must be Good, Right, and Successful and solution must be fit for purpose	5	3	0
GP10: Total cost of ownership	3	3	0
Corporate Asset			
GP11: Mainstream standards-based technologies	5	7	5
GP13: Scalability	7	3	5
Security			
GP5: The security of systems and data must be ensured	5	7	7
GP14: The operation of key business processes and systems must be ensured	7	3	5
Total:	**53**	**43**	**43**

Scoring Guide:
0=Doesn't meet principle
3=Falls short of principle
5= Satisfactory/Compliant
7=-Good/Very Good
10=Fully meets principle/goes beyond it

Figure 3 - Example Matrix 3

I. The Architecture Review Report

27. It typically falls to the chair of the review workshop to write the architecture review report during the days following the workshop. Whilst this contains, as appendices, the completed matrices, the focus of the report is on the outcome, and the insights that were gained during the workshop. It has the following structure:

28. The report has the following structure:

a) Introduction
b) Summary
c) Recommendations
d) Issues
e) Solutions
   - Description
   - Residual Risk score
   - Architectural Fit score
   - Falls short of x Principles
f) Matrices

J. Governance

29. The architecture review process is overseen by the ONS Architecture Review Board, which is answerable to a high-level executive committee. The governance of the process is therefore outside the governance arrangements for individual projects, and this arrangement gives architecture reviews a degree of independence from projects and their management boards, strengthening their ability to take a corporate view. Architecture reviews are mandated for projects under the ONS corporate development method, ONSide.

30. Once a draft report has been agreed by the members of the architecture review team, the report is passed to members of the Architecture Review Board for approval. From there, it is passed to the project board for consideration, usually via the project manager. The project board may accept the recommendations contained within the report, in which case the completion of the feasibility report follows, and the project would typically request permission from the investment board to enter the next stage of the ONSide process, High Level Solution Analysis and Design.

31. Provision has been made in the ONS Enterprise Architecture Charter for a project to dispute the recommendations of an architecture review. This is to cater for the situation where, for example, the architecture review takes a more strategic view, while a project board feels the need to adopt a more tactical approach, perhaps due to lack of funds or available time. In this situation, the high-level executive committee acts as a "court of appeal", and arbitrates between the competing points of view.

IV. ONS EXPERIENCE

K. Benefits of the method

32. Overall, the process has been a considerable success. It has helped spread understanding about the importance of architecture, both within the IT community, and among business sponsors and users. It has also fostered appreciation of the strategic direction of ONS among people whose primary concern is often to complete their project irrespective of wider considerations.

33. An important feature of the review process is its collaborative nature. There is a danger that it becomes an IT discussion, conducted by IT professionals, witnessed by business sponsors and users. The skill of the chair, who acts as a facilitator throughout the workshop, is critical to the success of the review.

34. Feedback from participants is regularly sought, and a selection of quotations from past participants below illustrates the wide range of benefits that have been experienced:

> "It really has moved things forward for my project"
>
> "Sometimes I even understood what was being discussed!"
>
> "It ensured that the project is not thinking too narrowly"
>
> "The review meeting helped Information Management Directorate to fully understand the business requirements"
>
> "The review reached a view on a proposal that business users and Information Management were in agreement for"

L. Difficulties

35. The strength of the review method is in its detailed comparison of competing solution approaches. Whilst many projects have no difficulty in developing multiple possible approaches (and there is often a "do nothing" approach open to the project), the method does not work well when there is only a single option on

the table, or when there is a desire to assess an existing solution. Several attempts have been made to adapt the key risk matrix (Matrix 2) to suit single solution reviews, and they have not succeeded. Matrix 3 is, of course, well suited to reaching a conclusion on the architectural fit of an existing solution.

36. Another complex trade-off, which reviews have tended to avoid considering directly, involves cost. A more expensive solution may be more compliant with architecture principles, or represent a lower risk, but does that necessarily represent the best solution, if a lower cost, slightly less compliant, solution is available with a slightly higher risk? Whilst a simple equation can express the degree of compliance or risk per unit of cost, this seems an over-simplification of the issue.

M. Conclusion

37. In addition to its application to software solution architectures, the approach has been used successfully as part of procurement exercises, where the results of the review contributed an agreed percentage of the overall score. It has also been used successfully for non-software solutions, an example being to assess the most appropriate location of systems servers following a decision to relocate business users to a different office.

38. At its heart, it is a collaborative approach to assessing the complex trade-offs involved when considering competing solutions and their impact on a multi-dimensional world. Many business evaluations, beyond assessing software architectures, would also seem to be well suited to this approach.

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