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Topic:

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Title:

Framework for Information Age Assessment Metrics

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Abstract

This paper presents the insights of John Zachman, the father of Enterprise Architecture, as they have been applied to the development and assessment of C4ISR systems. Specifically this paper discusses an Information Age Framework for Assessment Metrics and relates its elements to the fundamental facets of a C4ISR enterprise architecture.

Introduction

Defense acquisition has changed significantly over the last 20 years, especially with regard to Information Technology (IT). In the latter days of the Cold War the Department of Defense (DoD) was still a significant player in IT and developed significant computational hardware to address its needs. Since then the exponential growth in commercially available computing power and the equally significant drop in price has radically changed the landscape. Not only has stand-alone computing power been revolutionized but so has distributed computing due to advances in networking and middleware. Revolutionary new architectures are available today, which are reshaping not just the world of commerce but also government and the military.

This new world needs a new paradigm to discuss the dimensions of success.

In the Industrial Age the measures of success were *Better*, *Faster*, and *Cheaper*. When deciding whether to invest in a new mill or factory the owner would consider those metrics when determining his return on investment. What goes without saying in this view of the world is that the product is essentially the same, only Better, Faster, and Cheaper.

In the Information Age, where the network has replaced the steam engine as the primary organizing element, producing the same product Better, Faster, and Cheaper will result in a commodity. A commodity is a standardized item, which typically does not command a premium but rather trades at a price determined almost solely by supply and demand. Companies can, and do, make money in commodities, but it is generally a low growth, low margin, business where the market relentlessly demands efficiency.

The military equivalent of becoming a commodity in the Information Age would be still using carpet-bombing to prepare the battlefield. The size of the bombs might have increased; the planes may become more efficient in delivering ordinance; the dynamic of warfare would not have changed. The enemy would be able to adapt, collateral damage would be severe, and the “yield” of the bombing campaign would only marginally improve.

Precision strike with rapid retargeting is perhaps the most publicized example of Information Age concepts applied to warfare. Is it Better, Faster, and Cheaper? Absolutely, but those three measures are inadequate to measure the value of Precision Strike and are especially inadequate at identifying the contribution of C4ISR to enabling Precision Strike.

To identify the new return-on-investment (ROI) components for the Information Age we turn to one of the fathers of Enterprise Architecture, John Zachman.

Relationship to Enterprise Architecture

John Zachman spent his career at IBM leading large projects. In a bid to understand IT projects, and resolve problems related to coordination and comprehension that seemed endemic, he investigated other professions that successfully build complex things (skyscrapers and ships, specifically). From his investigation he was able to generalize the interaction of all these people into a simple schema. The people fit into a few common roles (namely, planner, owner, designer, builder, and subcontractor). These roles are represented as rows in his framework. The columns are based on the "six primitive interrogatories" (who, what, when, how, where, and why) and are paired to people (who), data (what), time (when), function (how), network (where), and motivation (why), respectively for IT. The framework is a powerful mechanism for resolving conflicts during project conception, coordination, and execution because each cell illustrates a unique relationship between role and interrogative pairs.

Without explaining the details of the Zachman Framework (ZF) Figure 1: Zachman Framework is a pictorial representation. The order of the columns is not important. The level of resolution and detail increases at lower rows. Additional details are available at ZIFA.com.

What is especially important about the relationship between the ZF and the Information Age metrics developed in this paper is that these relationships are meaningful to both developers and operators. Previous assessment approaches have focused on the operators in terms that are not meaningful to developers or to the way systems are developed. These approaches have either tended to be very academic and contain abstractions of questionable real-world value[1] such as "Physical, Belief, Environmental, and Reason". Or they are limited by an overly functional approach that does not adequately address the importance of data, motivation, distribution, and timeliness[2].

[1] Measuring the Effects of Network-Centric Warfare, under contract DASW01-94-D-0043, Delivery Order: 43, Options: 1AC, by Booz-Allen & Hamilton, 28 Apr 1999, (703) 902-5290.
[2] Assessment User Manual, Version 2.0, Joint Battle Center, 29 September 2000.

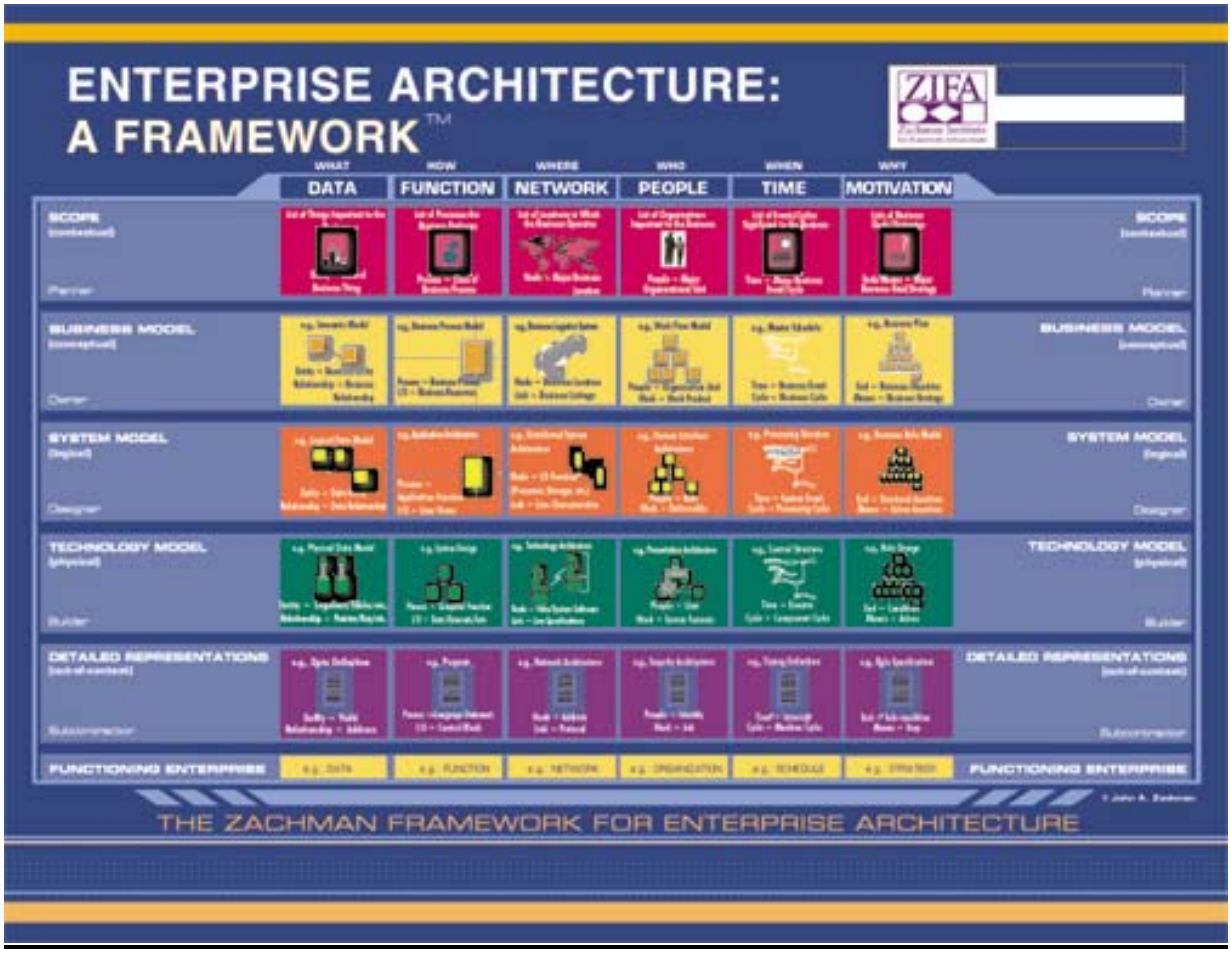

Figure 1: Zachman Framework

For project managers, system designers and engineers this framework offers benefits for understanding processes and how people interact during the different phases of design and development. One of the benefits of the Zachman framework is that it allows people to think of the bigger picture, as they work on their individual areas. In spiral development, for example, the framework can be used to help build requirements, offer insights into the roles of users, as well as serve as a useful tool for assessment or evaluation purposes.

During his symposium John Zachman identified *Integration, Alignment,* and *Flexibility* as the Information Age ROI metrics. This paper will describe how the Information Age metrics (integration, alignment, and flexibility) can complement the Industrial Age metrics (better, faster, and cheaper) in the design, development and evaluation of technologies.

The Metrics Defined

Users, both advocates and practitioners, of today's technologies can view these metrics below:

1. Quality (“Better”) - High quality produces display an absence of defects.

2. Timeliness (“Faster”) - The time required to execute a step in a plan.

3. Efficiency (“Cheaper”) - The ratio of output over input.

4. Integration
    a. Integration in Connectivity - The ability to exchange symbols between nodes (syntax).
    b. Integration in Meaning - When symbols are exchanged they convey the same content (semantics).
    c. Integration in Rules - When receiving the same content, under the same conditions, all participants will take appropriate action (cognitive processes).

5. Alignment - An aligned organization reflects the owner’s intent.

6. Flexibility - The ability of the enterprise to change with a minimum of disruption in terms of cost, schedule, or function.

Relating Information Age Metrics to the Six Primitive Interrogatories

To achieve Integration in connectivity it is necessary to have a “where” or network model that expresses the owner’s intent of where the enterprise will operate. This model will guide the designer in the development of the logical network model.

To achieve integration in meaning it is necessary to have a “what” or data model that expresses the owner’s intent of what the enterprise will operate on. This model will guide the designer in the development of the logical data model.

To achieve integration in rules it is necessary to have a “how” or functional model that expresses the owner’s intent of how the enterprise will operate. This model will guide the designer in the development of the logical functional model. Also closely related is the “why” model which captures the motivation and also environmental conditions (threats included).

To achieve alignment all the relevant architecture products must be understood (not all cells are necessary for every enterprise). Now, being understood does not mean explicitly capturing all in vast detail. Rather, the most important parts must have an 80% solution. If the owner has not clearly conveyed his desires and objectives it is unreasonable to expect the enterprise to reflect them. For this reason, alignment is particular dependent on a clear understanding by the staff (the “who”) of the owner’s motivation and goals (the “why”).

To achieve flexibility all the relevant products must be understood. Flexibility can be built in upfront; flexibility can also be provided for during the life of enterprise through

well-defined interfaces. Through either strategy it is important to understand objectives of the enterprise and the environment in which it will operate – the two components of "why". Also it is very desirable to separate inherent and accidental complexity. Accidental complexity arises from the solution and should not be part of the planners or owner's "why" model. Flexibility ultimately arises through all levels executing according to the paradigm of "tightly bound and loosely coupled" modules. These modules are defined by interfaces based on the "independent variables" of the six primitive interrogatories. Flexibility critically depends on understanding the relationship between the organization's goals ("why"), timeliness criteria ("when"), and product line ("what").

Figure 2 summarizes the most critical relationships that we have experienced in our development of C4ISR systems.

	who	what	when	where	why	how
Quality		x			x	
Timeliness			x			
Efficiency		x				x
Integration: Meaning		x				
Integration: Rules					x	x
Integration: Connectivity				x		
Alignment	x				x	
Flexibility		x	x		x	

Figure 2: Critical Enterprise Architecture - Information Age Metric Relationships

Applying Information Age Assessment Metrics to the Design Process

We have found that for distributed command and control systems applying the Industrial Age and Information Age metrics were very effective at identifying potential shortfalls and opportunities in the solutions offered by technologies and processes making up the C2 system. Far too often development teams are organized along the technical interest and expertise of team members for a specific COTS technology. This typically results in team members being too focused on their own COTS products as opposed to how their technologies or the total system would benefit users. While this is often a serious barrier to developing a usable system the introduction of the Information Age metrics can force technology teams to think outside their COTS-product stovepipes.

The following steps are suggested as guidelines for how to apply these metrics for more meaningful assessment of the capabilities that technologies offer today's users.

- A design process that identifies critical capabilities for the user complements the Information Age Framework for Assessment metrics.
- Hold discussions with each technology team to learn more about their technology and its relationship to the capabilities required.

  - This step is critical to ensure the technology team is focused outward on how to build a satisfactory solution for the user rather than performing "self-referential" design where they see the users as themselves.
- Discuss with each technology team how its standard features support the needed capabilities. This step is useful for identifying which metrics are pertinent to their technology.
  - Listing the individual features of the technology facilitates the discussion and selection of which features might support integration, alignment, and flexibility characteristics.
  - It is critical to perform a "gap analysis" to determine which features require further development or integration to support the required capabilities.
- For selected features, one can design assessment questions to gather feedback from users on how the technology supports their goals and needs in terms of the previously identified key capabilities.
- Once the data is collected, you can analyze the findings by comparing how the users judged each question and group your data according to the different metrics.
  - Degree of Integration, for example, may be illustrated by having no discontinuity in meaning, connectivity, or incomplete coverage of business rules. Designing assessment questions around the degree of consistency in terms and taxonomy, or degree of connectivity between users, or degree to which business rules are implemented can offer insights into how well your technology offers integrated solutions within the C2 system.
  - Alignment can be expressed as the degree of unity or shared situational awareness among system users. Alignment metrics will contribute to mission accomplishment.
  - Flexibility metrics can be created that show ability to adapt to changes in the environment and still provide the required capability while measuring the degree of cost, schedule impact, or functional/feature degradation.
- Further review and analysis of your data allows you to extract additional meaning from the findings.
- This process can also be applied to development of operational metrics to be incorporated in a management digital dashboard or knowledge management system.

Summary

All technologies that are relevant at the enterprise level are fundamentally rooted in the six primitive interrogatories and therefore can be evaluated by some or all of these metrics. This framework offers an excellent starting point for better design and development of technologies for C2 systems. In a spiral development process design and assessment are adjacent phases and both profit from this powerful intellectual construct. Both the strengths and weaknesses of a particular technology can be the stimulus for a successful integration that provides the capabilities that will satisfy the needs and goals of the users.