A WHITE PAPER FOR BUSINESS AND TECHNOLOGY PROFESSIONALS

# Understanding Systems Architecture A BUSINESS BRIEF

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## Abstract

During the first four decades of business computing, the scope and complexity of most applications were limited to standalone solutions. Limited machine resources further constrained these systems. Architecture was implicit and of little interest to the day-to-day affairs of IS. Today, technological advances and their associated financial improvements make it possible to conceive and to build information systems capable of supporting streamlined business processes that span a major business area or the entire enterprise. Companies are grappling with how to develop next generation information systems—not necessarily because they want to or just because they can, but because the new competitive environment mandates change.

As businesses place more and more demands on their underlying information systems, the complexity of these systems rapidly becomes overwhelming. IS must not only cope with escalating complexity, but must provide leadership for managing business change. Systems architecture is key to the ability of IS to translate increasingly complex business requirements into adaptive information systems just as traditional architecture is key to translating the space requirements of business into effective work environments. Today, systems architecture is a strategic business responsibility of IS regardless of the technologies and platforms used to develop systems. Systems architecture provides the blueprint for mapping technology onto the real-world requirements of business. It produces mental representations that are intelligible to all the information systems participants: business managers, designers and builders.

This business brief presents an analogy between traditional building architecture and systems architecture by showing the steps required to build an office complex and relating the activities of a building architect to those of a systems architect.

## **Architecture's Role**

A bicycle shed is a building, but Lincoln Cathedral is a piece of architecture. Nicholas Pevsner

There is an urgent need for a comprehensive, rigorously developed computational theory of design that can provide an adequate basis for practical software development work. William J. Mitchell, The Logic of Architecture

Both architects and business managers live in ill-structured, unbounded worlds where analytic rationality is insufficient and optimum solutions are rare. Both have perspectives that are strategic and top-down. Top managers, like chief architects, must architect strategies that will handle the unforseeable, avoid disaster and produce results satisfactory to multiple clients—to boards of directors, customers, employees and the general public. Their common modus operandi is one of fit, balance and compromise in the overall interest of the system and its purposes.

Eberhardt Rechtin, Systems Architecting

Innovation is power, and information enables innovation. Corporations are struggling with exploding demands for information. Competitive pressures make it necessary to connect islands of information, resources and people into a cohesive whole. New era applications—workflow, collaboration, electronic data interchange, on-line imaging and intelligent documents—can enable business process innovation and alter a company's position in its industry's value chain. The new business objectives demand a fully integrated information framework and infrastructure. Most CEOs and CIOs recognize the business imperative for next generation information systems that can span major business areas or an entire enterprise.

Unfortunately, today's application approaches are simply incapable of handling the requirements of next generation business computing. Organizations built their existing islands of information with incompatible proprietary hardware, software and networks. Today, they cannot integrate these information islands. The same information residing in different systems has different meanings—the context within each system determines the information's meaning. The islands do not scale to handle workloads that span major business areas or the enterprise. The very thought of integrating these disparate systems conjures up a nightmare of complexity.

These legacy information resources, however, contain great business value both in the functions they perform and the business information they contain. As any successful business investor would argue, these are valuable assets, which provide the lifeblood of current business operations. Exciting new technologies seem to offer breakthrough advantages—distributed object computing and fine-grained client/server architectures offer the promise of superior and more cost-effective solutions for tying existing islands of information into a cohesive whole. But the business case dominates the technology case: How do we successfully develop, maintain, enhance and change complex systems given

our historically poor track record? It is little wonder the challenge of migrating to next generation information systems is such a difficult business decision.

Many forward-thinking organizations recognize that object technology holds promise for making next generation computing a reality. Object technology and finegrained client/server architectures can help put our nightmares to rest by helping manage complexity. They allow partitioning both the business and technical domains into

their component parts *(decomposition)*, keeping unrelated activities separate *(decoupling)*, and hiding implementation details *(encapsulation)*. Decomposing and decoupling components enhance the potential for reusing these components. Encapsulation simplifies system maintenance and enhancement. Together, they provide the means for developing flexible, adaptable, evolving information systems. Along with making the semantics of the business visible in software, these techniques additionally allow for successfully integrating legacy assets with next generation systems. Indeed, these new technologies are inviting to business, but technology is a double-edged sword.

### **The Need For Systems Architectures**

Distributed object computing (the combination of object technology with fine-grained client/server architectures) makes it possible to develop adaptive information systems and to distribute computing power throughout an enterprise network. But these

A key aspect of applied first principles is the understanding that business decisions drive most architectural decisions.

technologies alone will not provide a competitive advantage. Realizing the advantage of next generation business computing requires an overarching structure-an architecture-that rationalizes, arranges and connects components to produce the desired functionality both now and in the future. In most businesses, these components include prior, current and emerging generations of technologies and applications. Without architecture, distributed computing in a heterogeneous environment is certain to result in distributed chaos. Developing a systems

architecture, therefore, is not an option but a necessity for successfully implementing complex, next generation systems. Without architecture, the software crisis—the inability to build enough software, on-time and with sufficient quality—will continue.

Further, systems architecture provides a framework for designing changeable systems even when these systems do not span the entire enterprise. Information systems must be able to respond to changes in the business and in technology. The need for systems to evolve over time and the requirement for ongoing enhancements and maintenance create growing complexity in information systems. A good systems architecture provides a framework for change—and change is one of the few constants in today's business world.

Traditional architecture and systems architecture use similar processes for developing their respective endproducts. Traditional architecture results in physical buildings and structures. The architect calls upon architecture's *first principles*<sup>1</sup> and combines them with the experience of doing architecture in the real world. Whom do you want to design *your* new office complex—an architect fresh out of school or one who also has practical architectural experience? The experienced architect works with applied first principles. Applied first principles add practical experience and integrate fit, balance and compromise into the architectural process. In school, architects are first taught lessons and then given tests. *In the real world, architects are given tests first, and then the lessons follow.* One internationally renowned architect told of how he "starved" until he reached age 42; one cannot learn applied first principles overnight.

There is no single, general-purpose architecture that is correct for every situation. There are, rather, different styles—styles that change and come into and go out of favor over time. Architectural style is the way in which something is said, done, expressed or performed. It is a quality of imagination and individuality expressed in one's actions and tastes. Style creates the sense of a unified whole from separately developed—both in time and in space—human artifacts, be they buildings or software. In traditional architecture, we recognize the styles of noted architects and periods—for example, the Frank Lloyd Wright and Baroque styles of architecture.

A systems architecture results in information structures. A good systems architecture is the secret to gaining the competitive advantage through less expensive, faster and better information systems. Systems architectures are the linchpins needed for systems that successfully span an enterprise and embrace change.

Qualified systems architects possess applied first principles including the understanding that most architectural decisions are driven by business decisions, particularly business investment decisions. The cost of developing a systems architecture is a relatively small fraction of the total enterprise information systems cost. It does, however, provide the necessary structure and rationale for making the investment decisions.

Systems architectures have their own styles just as do building architectures. Aesthetic demands and technological improvements influence systems architectural style. Layering, isolating volatility, establishing protocols, and technological improvements, such as distributed object technology, strongly influence today's architectural styles.

Placing a system within a context and using it within that context are what makes architecture important. The enterprise that successfully designs complex systems appreciates the need to match process and style with the organization. What if we simply ignore architecture and continue to build more information systems as we have done in the past? The Winchester House, near San Francisco, is an example of constructing a building without an architecture. The similarities between the Winchester House (see inset) and many of today's information systems are all too obvious.

The enterprise that recognizes the importance of

A popular tourist attraction in the San Francisco Bay area, the Winchester House, is a result of nonstop construction spanning a 38-year period and which consumed vast resources. Supposedly haunted by ghosts of those poor souls killed by rifles made by her husband, Mrs. Winchester turned to her spiritual advisors who told her that she would live as long as she continued to build her house. Today, people tour the mansion that has, as its highlights, a chimney that does not quite reach the roof, doors and windows shut off by walls, a greater number of hallways than rooms and stairways that lead to ceilings.

<sup>1</sup> First principles are axioms, laws or abstractions that represent the highest possible degree of generalization.

systems architecture needs to ask several fundamental business questions: What business problem does architecture solve? What is the value added by having a systems architecture? What are appropriate architecture investment levels? What are the tangible results, i.e., deliverables of a systems architecture?

### The Essence of Systems Architecture

All systems have an underlying architecture or logical scheme for defining their interfaces and arranging their components. Today, most systems architectures

are *implicit*, but next generation business systems require that systems architectures be made *explicit*.

Nature is an example of what happens without an explicit architecture. Replication with random variation in a selective environment is the process that determines which species survive. Through natural selection, some variations prove valuable and survive; others do not and die out. Millions of years go into selecting the valuable variations. The result has the appearance—but only the appearance of an architecture, a seamless whole to which each component effectively and efficiently contributes. Information systems do not have this amount of time to evolve and to rely on natural selection. Having a logical construct, a blueprint—an *architecture*—removes the randomness from the process. An architecture allows us to avoid spending time and effort developing systems only to find out later that they are not valuable and are dead-ends.

Business organizations also have an underlying architecture.

Systems architecture goes beyond any individual technology and provides the foundation for integrating disparate resources into enterprise solutions. For example, an organization's chief financial architect is its CFO. Rather than designing buildings, CFOs develop architectures generally using work breakdown structures. Arranging and connecting the concepts and semantics of corporate tax accounting, investment portfolio management, cost accounting and bookkeeping help ensure the financial organization's effectiveness and efficiency. The successful CFO is a successful architect who synthesizes the right components to build solid financial structures for serving the corporation.

The architectural framework needed for information systems

probably will not come from within the IS community. *Architecture* is an emotionally charged word within this community: We have vested job interests in network architectures, client/server architectures, software architectures and the like. Yet traditional architecture, with 2,000 years of evolution, provides a relevant model. IS can adopt the ideas contained within traditional architecture and apply its definitions, notions and first principles to systems architecture. Increasing numbers of forward-thinking systems architects have, on their personal bookshelves, classic architecture books by recognized authorities such as U.C. Berkeley's Christopher Alexander and Harvard's William Mitchell.

With *Next Generation Architectures*, we can meet the challenge of enterprise computing by integrating current and emerging technologies. Systems architecture goes beyond any individual technology by providing the foundation for integrating disparate resources into solutions with an enterprise reach. Architecture addresses the

selection, connection and arrangement of components to produce a desired result—a result that is much greater than the sum of its parts. Today's new and existing components—hardware, software, networks and applications—are disparate, scattered and isolated. Tying them together can appear to be overwhelmingly complex, but an explicit systems architecture can provide the framework for helping to manage this complexity.

How does a systems architect create a successful architecture? To answer that question, this business brief presents the analogy of developing an architecture for an office complex and relates the steps a building architect follows to those a systems architect follows.

# **Architectural Analogy**

eveloping an architecture for an office complex provides an easy-to-follow analogy for the process of creating a systems architecture. We turn to the imaginary Tennis Research Corporation, Inc. (TRCINC) to provide us with the analogy.

A couple of Harvard drop-outs who had a better idea for tennis racquets began TRCINC. After gaining initial market acceptance, TRCINC became wildly successful. Over a very short period, the company experienced rapid growth and diversified, grabbing the attention of Wall Street. Today, the company has headquarters located next to a cow pasture in Florida and has departments scattered throughout the United States: Advertising in New York City, Procurement in San Francisco, Manufacturing in Detroit and Distribution in Atlanta.

Halfway into its fifth year of operation, its CEO, Matt Allbright, noticed the first negative blip on the screen — productivity had begun to fall as a result of its scattered operations. Looking out at the cow pasture, he envisioned a new office complex that would integrate TRCINC's disparate resources into a consolidated, lean mean productivity machine capable of sustaining leadership in TRCINC's fast-paced industry.

TRCINC called upon a renowned architect to design and to build a new office complex. To meet the overall requirements of the corporation, Matt asked that the new office complex use the existing office buildings where possible and support the company's expected growth.

We will follow the process the architect used for designing and building the new office complex.



Today



Tomorrow

## **The Architectural Process**



RCINC's architect is going to construct the new office complex by completing a three-phase architectural plan. Each phase describes the same entity, the office complex, but views the entity from the perspective of the process' different participants—owner, designer and builder. Many of these ideas were first formulated in 1987 by IBM's John Zachman (see Suggested Readings).

1. Owner's View. The first phase develops an understanding of TRCINC's requirements and produces conceptual renderings of the office complex. The representation is from the owner's perspective. Renderings show an office complex that captures all of TRCINC's perceived requirements. The equivalent systems architectural component is a business model that describes the architecture from the view of the business, not from the view of IS.

2. Designer's View. The second phase produces the designer's view (preliminary blueprints and bills-of-materials) and assesses existing resources. The view translates TRCINC's requirements and perceptions into a design for the office complex. It is the architect's representation of the complex and provides a specification of the materials used. It is the basis for developing the builder's view during the next phase.

**3. Builder's View.** The third phase develops blueprints, bills-of-materials and construction plans. These

### DEVELOPING AN OFFICE COMPLEX ARCHITECTURE

I. Develop Owner's Renderings

- 1. Determine building requirements, goals and constraints
- 2. Prepare architectural renderings

#### II. Develop Design Plans

- 1. Develop preliminary blueprints and bills-of-materials
- 2. Assess existing buildings and other resources

#### III. Develop Builder and Shop Plans

- 1. Prepare detailed blueprints and bills-of-materials
- 2. Perform testing and evaluation
- 3. Prepare construction plans

### **DEVELOPING A SYSTEMS ARCHITECTURE**

I. Develop Business Architecture

- 1. Determine business requirements, goals and constraints
- 2. Prepare proposed business architecture

#### II. Develop Information Systems Model

- 1. Determine system architecture description and proposed functional components
- Prepare information systems model, which includes assessing legacy systems, technical infrastructure and implementation options
- III. Develop Technical and Implementation Architectures
  - 1. Specify process framework and detailed component list
  - 2. Do proof-of-concept project
  - 3. Prepare implementation plan

#### Table 1 Architecture Phases and Steps

are the detailed plans for building the office complex. They reflect applying the realities of existing resources and constraints to the conceptual renderings. They are the detailed blueprints—site, electrical, plumbing, masonry, etc.—of the entire complex. The building contractor and sub-contractors will use them for constructing the complex. Table 1, "Architecture Phases and Steps," shows the three phases and the seven steps that implement them. In this and the following Tables, the left columns describe traditional architecture activities, and the right columns describe equivalent systems architecture activities.

### 1. Determine Building Requirements, Goals and Constraints

The first step is the most difficult. Uncovering the new office complex's true requirements is perhaps the most challenging task faced by the architect. TRCINC has general, high-level notions of its requirements. The architect must apply analytical methods and rely on his experience to flesh out the true requirements. The

architect must incorporate the overall requirements into TRCINC's specific goals and constraints. What is the purpose of the new office complex? What is the required functionality? What are its limiting factors and constraints?

### **OFFICE COMPLEX REQUIREMENTS**

Provide adequate space for employees to conduct business. Provide meeting rooms for employees and guests. Reduce costs of operating multiple locations. Use existing Florida property.

### **INFORMATION SYSTEMS REQUIREMENTS**

Provide enterprise-wide information access. Allow for developing reliable systems in a timely manner. Electronically interact with customers and suppliers. Leverage legacy system investments.

### **OFFICE COMPLEX GOALS**

Improve efficiency and workflow by grouping staff by work unit. Allow for normal business operations when building new office complex. Control heating and air conditioning costs. Use existing wiring for voice and data.

### **INFORMATION SYSTEM GOALS**

Reduce application development time by 50 percent. Reduce processing, retrieval and storage time by 30 percent. Reduce the time for doing research and development. Implement reengineered processes.

### **OFFICE COMPLEX CONSTRAINTS**

Must house 500 employees. Zoning limits building to fifteen stories. Lot size is five acres. Must meet building and environmental codes and regulations. Working with fixed budget. Competitors have on-site demonstration facilities; we need them, too.

### **INFORMATION SYSTEMS CONSTRAINTS**

Must support 500 users. Users are at ten facilities throughout the United States. Data Center is in New York. Must meet government regulations and reporting requirements. Working with fixed budget. Competitors have Internet access for customers; we need it, too. Goals reflect activities that will improve TRCINC's bottom line. Requirements differ from goals in that an architecture either meets or does not meet a requirement. The architect and owner, on the other hand, use a scale to measure goals. It is possible to completely achieve, to partially achieve, or not to achieve a goal. Goals can conflict with one another. The architect, along with TRCINC's management, determines which goals to satisfy and to what extent to satisfy them.

#### Constraints are factors unaf-

fected by architectural changes. Constraints differ from requirements and goals in that they involve factors from the larger world outside the office complex's design space, such as building codes and site layout. Constraints identified during this phase directly relate to the business; they are not resource or technology constraints. Later phases will identify resource and technology constraints.

Some things that first appear to be constraints may not, in reality, be constraints; they may be opportunities. For example, the possibility that customers refuse to change tennis racquets more frequently than once every three years is a concern to TRCINC. This, if true, will limit TRCINC's growth and its need for additional manufacturing facilities. What at first appears to be a constraint may actually be an opportunity for developing new and improved marketing strategies. It may be possible, for example, to convince players that they

An architecture incorporates three representations, each from a different perspective — the owner's, the designer's and the builder's. need different racquets for playing under different conditions.

The architect studies the requirements, goals and constraints. The first architectural deliverable is an initial representation (Zachman refers to this as a *bubble chart*) that depicts, in gross terms, the shape, size, spatial relationships and essential purpose of the office complex. Requirements, goals and constraints define the *ballpark* within which further design work takes place. Interaction and conversation between the architect and Matt

Allbright must convince Mr. Allbright that the architect fully understands the intent of the new office complex. From this definition of the project's scope and objectives, the architect and TRCINC have a common ground from which the architect can move forward.

### 2. Prepare Architectural Renderings

During this step, the architect develops and presents one or more possible sketches, scale models and renderings of the new office complex. The architect repeats this process until the client, TRCINC, and he agree upon the broad outlines for the design. Renderings are a representation of TRCINC's view of the complex. When developing the renderings, the architect takes into account all the business requirements, goals and constraints. This helps ensure the design accommodates the needed functionality.

The architect must present possible solutions with sufficient clarity so the client can envision the proposed solution. As happens in so many arenas, *the client will know the solution when he sees it.* 

The architect adds his training, experience, style and æsthetic senses to the client's requirements, goals and constraints. Equally important, the architect brings unarticulated assumptions to the process. Consider the variety of structures people throughout the world use for offices. Imagine describing such a structure simply in terms of its requirements, goals and constraints. The person describing the structure may have a good—but unarticulated—idea of what its appearance "should be." The architect gives these assumptions substance and helps develop the same mental images with architectural renderings. The same problem occurs when developing information systems. The user, the client, has unarticulated ideas of what the system "should be." It is the business model that helps ensure both the systems architect and user have the same understanding and vision of the new system.

Architectural renderings, conceptual drawings and scale models help bring a meeting of the minds on a form that will accommodate the function. They help the client to envision how the office complex may look after initial construction and, perhaps years later, after completing an entire master plan.

### **ARCHITECTURAL RENDERING**

Shows the office complex as it exists within its environment. Contains floor plans with major features, workspaces and facilities. Includes representations showing the complex's artistic motif.

### **CONCEPTUAL SYSTEMS ARCHITECTURE & BUSINESS MODEL**

Bounds the system within the real world. Presents a high-level, business-oriented systems representation. Presents conceptual user interfaces.

### 3. Develop Preliminary Blueprints and Bills-Of-Materials

The representation shifts to the designer's view during this step. The architect combines the requirements, goals, constraints and renderings to create the designer's preliminary representation of the office complex. This representation may include specifications for site-work, heating and air conditioning, electrical and masonry. These plans will serve as the basis for communicating and negotiating with the builders.

The architect develops the preliminary bills-of-materials by studying the requirements, goals and constraints in light of the current blueprints. The architect generates several ideas for plans and materials. After synthesizing the promising ideas, he subjects them to rigorous analysis before selecting the best ones. Applied first principles are essential to the process. The architect subjects the components, requirements and constraints to financial analysis. He weighs and re-weighs them by using a combination of *art, science* and *finance* to arrive at the optimum architectural and functional solutions that exhibit the maximum return-on-business-investment. This returnon-investment is the return from investing in an architecture.

### PRELIMINARY BLUEPRINTS

Floor plans that facilitate communication among business units, privacy when necessary and material and information flow.

### PRELIMINARY BILLS-OF-MATERIALS

Best materials for the office complex based on the properties of the materials and on cost/benefit analysis.

### **ARRANGEMENTS AND CONNECTIONS**

Translates business domain into information system domain. Specifies the best arrangement for information, software and technical components.

### **COMPONENTS LIST**

Best system components for architecture based on the attributes of the components and on cost/benefit analysis.

#### Table 4 Preliminary Blueprints and Bills-Of-Materials

### 4. Assess Existing Buildings

Before preparing the detailed design plans, the architect assesses the existing buildings and facilities and presents TRCINC with options for integrating the existing structures into the new office complex. If existing structures provide value, the architect integrates them into the plan. If they are impractical, he eliminates them from further consideration. As an example, TRCINC recently remodeled and renovated two of its headquarters' buildings. Can TRCINC leverage these assets by including them in the new office complex?

Notice that the architect did not start by analyzing the existing buildings. He started by determining requirements, goals and constraints. This distinction is vitally important. He wanted to be unbiased while studying the requirements, goals and constraints. Now, however, is the time to conduct an in-depth assessment, which allows basing recommendations on the *business case* for

incorporating existing assets as opposed to basing them on preconceived notions either in favor of or against the existing buildings.

After reviewing and analyzing the existing headquarters buildings, the architect presents TRCINC with the opportunities for integrating, eliminating or salvaging some of these structures. At this stage, Matt Allbright has sufficient information with which to make sound business decisions about the existing assets.

Before moving forward, TRCINC and the architect must agree on the best way to achieve the proposed model. With the target design in view, both parties should be able to agree on the best course of action.

Including existing buildings in the new office complex represents one of the few times that a business can

### EXISTING BUILDINGS ASSESSMENT

Inspect existing buildings and furnishings.

Determine state of existing headquarters buildings.

Determine which existing furnishings to use in new office complex.

Balance architectural and financial requirements for integrating existing facilities.

### LEGACY SYSTEMS ASSESSMENT

Conduct legacy systems architectural assessment.

Determine state of current systems architecture.

Evaluate other resources (hardware, software and telecommunications) available for building new systems.

Determine which legacy assets to incorporate into new systems architecture.

Balance architectural and financial requirements for integrating legacy systems and other resources.

Table 5 Existing Buildings Assessment actually *increase its rate-of-return* on its existing assets. For example, the new office complex may increase the value of the existing buildings. It may be tempting to always include existing assets, but sound business decision-making requires rigorous analysis of existing (legacy) assets that considers the near- and long-term requirements of the office complex.

The same integration issues face the systems architect. Corporations have significant investments in legacy system assets. Systems architects and users must make rational decisions about which legacy systems to include in new systems architectures and the best methods for integrating them. A first principle of finance is "sunk costs don't count" when making new or additional investment decisions. The same applies when reviewing legacy systems. They only have value in terms of their future contributions, not in terms of their past costs.

### 5. Prepare Detailed Blueprints and Bills-Of-Materials

This step produces TRCINC's bottom line needs of what it must spend to construct the new office complex. The architect moves the project from a design perspective to a construction perspective. He identifies the final resources for constructing the complex by subtracting existing resources from the preliminary bills-of-materials. The representations produced during this phase are for the builders and subcontractors.

It is during this step that the architect makes *buy-or-build decisions*. Others may have elegant solutions to some of the problems that exist within the architecture under design. The architect must evaluate the benefits of using these solutions versus developing a new solution. If the architect finds that an existing solution

is proper, the client, TRCINC, saves the cost of researching and developing a new solution.

The client, whether a building client or a systems client, should expect changes and should be ready to accommodate them. A communication system architecture may substitute fiber optic cable for copper wiring. A legacy system originally designed to use a relational database can be part of a new systems architecture by encapsulating the database and presenting an object-oriented interface to new system components. The relational database can coexist with object databases, which can result in substantial speed and cost savings.

### **DETAILED BLUEPRINTS**

Compares initial blueprints with existing buildings and determines which requirements are not being met by existing buildings.

Provides site plans.

Provides detailed floor plans showing all components.

Provides phased plan for building new office complex.

Shows how to incorporate existing components into new buildings.

### **TECHNOLOGY ARCHITECTURE**

Compares initial blueprints with infrastructure inventory and determines what requirements are not being met by legacy systems.

Uses standard, off-the-shelf components whenever possible.

Describes detailed technical architecture, classes and objects, and object interactions.

Provides phased implementation plan.

Shows how to incorporate legacy assets into the new system.

Table 6 Detailed Blueprints

### 6. Perform Testing and Evaluation

The architect has documented all relevant data; client and architect have agreed upon the blueprints; the architect has assessed the existing structures and specified the bills-of-materials. The architect is now ready to synthesize all this information into a proof-ofconcept model. Good architects always test their designs before beginning real construction. They want to know that the buildings will stand up to both earthquakes and hurricanes. Testing should use the best and most current methods available. This can include: building scale models; using computer simulations; and prototyping portions of the buildings. Historians tell us that even the ancient Egyptians built scale models of the pyramids and stress tested them before construction.

Airplanes, for example, go through a final testing and wind tunnel evaluation before being put into production. The airplane manufacturer conducts extensive computer simulations even before the wind tunnel tests. The building construction industry performs similar testing and evaluations. A successful simulation proves the concepts to all interested parties. These tests are critical to proper *risk management*, which, in turn, is critical to sound business management.

### FINAL TESTING AND EVALUATION

Develop scale models.

Perform computer simulations.

Build (prototype) portions of the buildings.

Test critical components.

### **PROOF-OF-CONCEPT PROJECT**

Stress test critical infrastructure components. Prototype key portions of the system. Simulate software, hardware, telecommunications interactions and processing loads. Prototype user interfaces.

Table 7 Perform Architecture Testing

### 7. Prepare Construction Plans

Now that the architect has proven designs, it is time to plan and to schedule the actual construction. The architecture allows for decomposing and decoupling individual components, for developing them in parallel and, most important, for producing an integrated whole—whether it is a building or a system.

*Change management* allows the project supervisors to coordinate changes with all affected activities. Quality assurance ensures that the actual office complex matches the complex represented by the blueprints. *Quality assurance* provides measures of progress at regular intervals. It provides the management controls that help ensure the project stays on schedule and follows the blueprints, while at the same time allowing

for unforeseen change. An essential measure of an architecture's quality is its ability to accommodate change.

The design is complete. But the world is constantly changing, so the final product will probably not exactly match the original plan. This should not be a source of alarm. Many buildings undergo change as conditions during construction change. *Change* is a critically important concept of good architecture. Quality and the ability to gracefully handle change are two characteristics essential to good architecture, good business and good technology.

### **CONSTRUCTION PLAN**

Contains detailed assembly and fabrication drawings. Provides numerical control tool specifications (if required).

Specifies metrics for quality assurance.

Specifies change management process.

### **IMPLEMENTATION PLAN**

Specifies detailed program module descriptions. Specifies physical database structures and optimization methods. Specifies detailed network architecture. Defines metrics for measuring quality. Specifies change management process.

Table 8 Construction Plan

## Conclusion

Investments, whether in new buildings or new information technology, must meet strict return-on-investment criteria: risk management, ability to support change, and cost/benefit ratios. Individual investments are simple and straightforward. Large investment portfolios are complex, requiring analytical methods and techniques to ensure optimal return on the portfolio's overall investment, and to balance its assets.

Architecture is a discipline that addresses complexity by arranging and connecting individual components in a way that globally optimizes the results. Whether developing an architecture for a building or an information system, the architect must carry out the steps in the process in the correct sequence and in adequate detail. Without following these steps, design decisions will not correspond to the available information, and this information will not support the decisions.

The seven steps of the architectural process provide a framework for information gathering, analysis and business decision-making. The example of developing an architecture for an office complex produces a set of architectural representations. The client, the architect and the builder require unique representations that meet their individual conceptual and semantic needs. All three are observing the same entity, but they need representations unique to their perspectives. The representations are not a matter of adding more detail at each step in the process. Rather, the representations differ in their very nature—they differ in their content and semantics. They serve the unique perspectives of each participant.

Systems architecture is the secret to gaining a business advantage from next generation technology. Systems architecture provides the organizing principles needed to manage overwhelming complexity inherent in next generation information systems. Systems architecture provides the blueprint for mapping technology onto the real-world requirements of business. Business and technology professionals responsible for charting the future of their organizations should build that future on a solid systems architecture.

# **Suggested Readings**

any people are researching the impact emerging technologies has on systems architecture. This is a list of references of current research and a few of the pivotal works that can significantly influence those who develop information systems architecture.

Rechtin, Eberhardt, Systems Architecting: Creating and Building Complex Systems, Prentice-Hall (1991).

Shaw, M. and D. Garlan, *Software Architecture: Perspectives on an Emerging Discipline*, Prentice Hall (forthcoming).

Software Engineering Institute at Carnegie Mellon University. Technical Reports are available through Research Access, Inc., 800 Vinial Street, Pittsburgh, PA 15212, USA, (800) 685-6510. SEI is on the Web at http://www.sei.cmu.edu/.

Spewak, Steven H., *Enterprise Architecture Planning*, Wiley (1992).

Zachman, John A., "A Framework for Information Systems Architecture," *IBM Systems Journal*, Vol. 26, No. 3 (1987), pp. 276–292. Available from IBM T. J. Watson Research Center, PO Box 218, Yorktown Heights, NY 10598, (914) 945-3836. This paper is the result of an effort to improve IBM's Business Systems Planning (BSP) and Information Planning Strategy (ISP). Many consider the Zachman Framework to be a *de facto* architectural standard for commercial information systems. Although Zachman developed his framework before the object paradigm, it provides useful background information for systems architects.

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