Chapter 1: Software Architecture

Architecture Business Cycle

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A Conceptual Roadmap to Software Architecture

Software Architecture Model

Design Pattern Models

typing | concurrency | persistence

abstraction | **hierarchy**

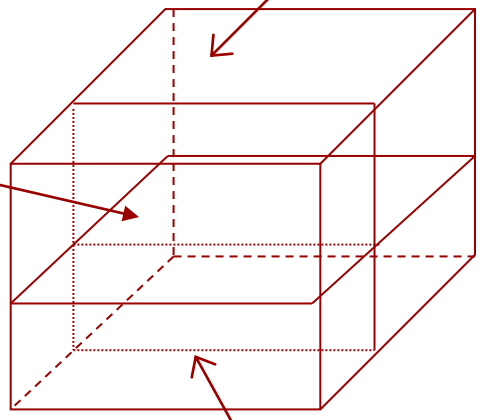
encapsulation | **modularity**

Object Model

UML Model

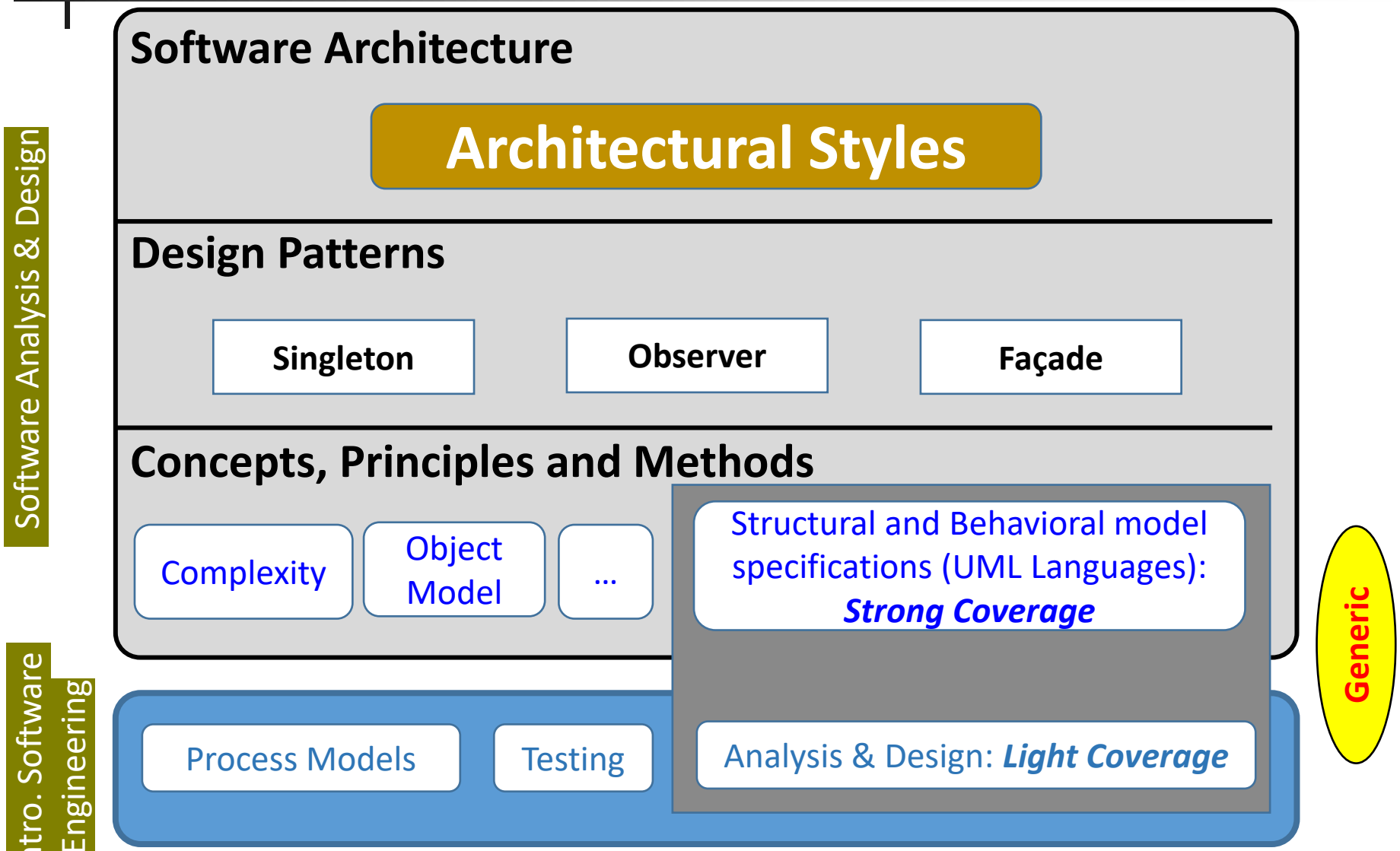
Logical/Dynamic:
interaction, … diagrams

Logical/Static:
Class, … diagrams



Physical/Static:
Component, … diagrams

Design Patterns: Specific



Software Architecture: Some Initial Observations

- Software architect task is to envision the skeleton of a software intensive system based on a wide range of competing and usually conflicting demands
  - Individuals, corporations, and governments are stakeholders in the development of software architectures
    - Architecture represents a set of **business**, **technical**, and **social** decisions
- Lifespan of software architecture by definition is open-ended!
  - Software architecture is expected to be a living artifact – it should lend itself to evolve within some reasonable bounds (e.g., cost, performance, usability, extensibility, etc.)

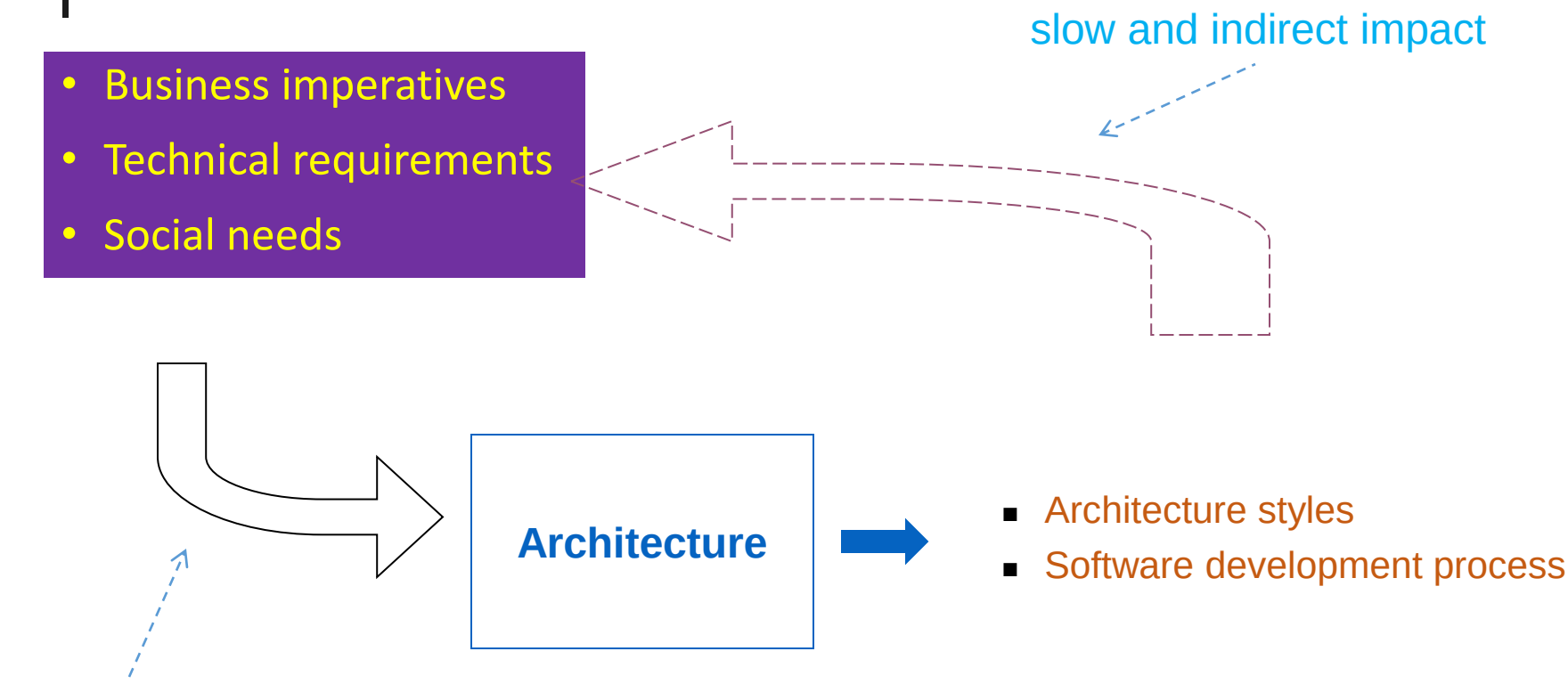
Architecture Business Cycle

- Architecture is expected to **serve** the following needs
  - Communication
  - Analysis
  - Reasoning
  - Software evolution

- Architecture is shaped due to **influences** from three factors
  - Business imperatives
  - Technical requirements
  - Social needs

- Software architecture **affects** business and social landscapes

Architecture Business Cycle (cont.)



Software architecture is a necessary artifact for building large-scale software-intensive systems

Stakeholders

Architects (and therefore software/system architectures) **are influenced by stakeholders**

- Marketing
  - Cost
  - Time to market
  - Market share
  - Competitive strategies and practices
- End-user
  - General, ordinary individuals
  - Technical individual – e.g., system admin., developer, …
- Customer
  - Generally has conflicting demands with end-user (cost vs. usability)
- Maintenance organization
- Technical environments
- Developing organization
  - Organizational imperatives

Technical environment considerations

- Resources
  - Hardware & software technologies (e.g., system-on-a-chip, J2EE), tools (Eclipse Graphical Modeling Framework, GitHub) , and standards (e.g., UML, MDA, Service Oriented Architecture, …)
  - Human/intellectual capital – expertise in software engineering architecture
    - Distributed computing
    - Multi-tier architecture
    - Large-scale software development
    - Project management
    - Software safety
    - Ubiquitous/Wireless technologies

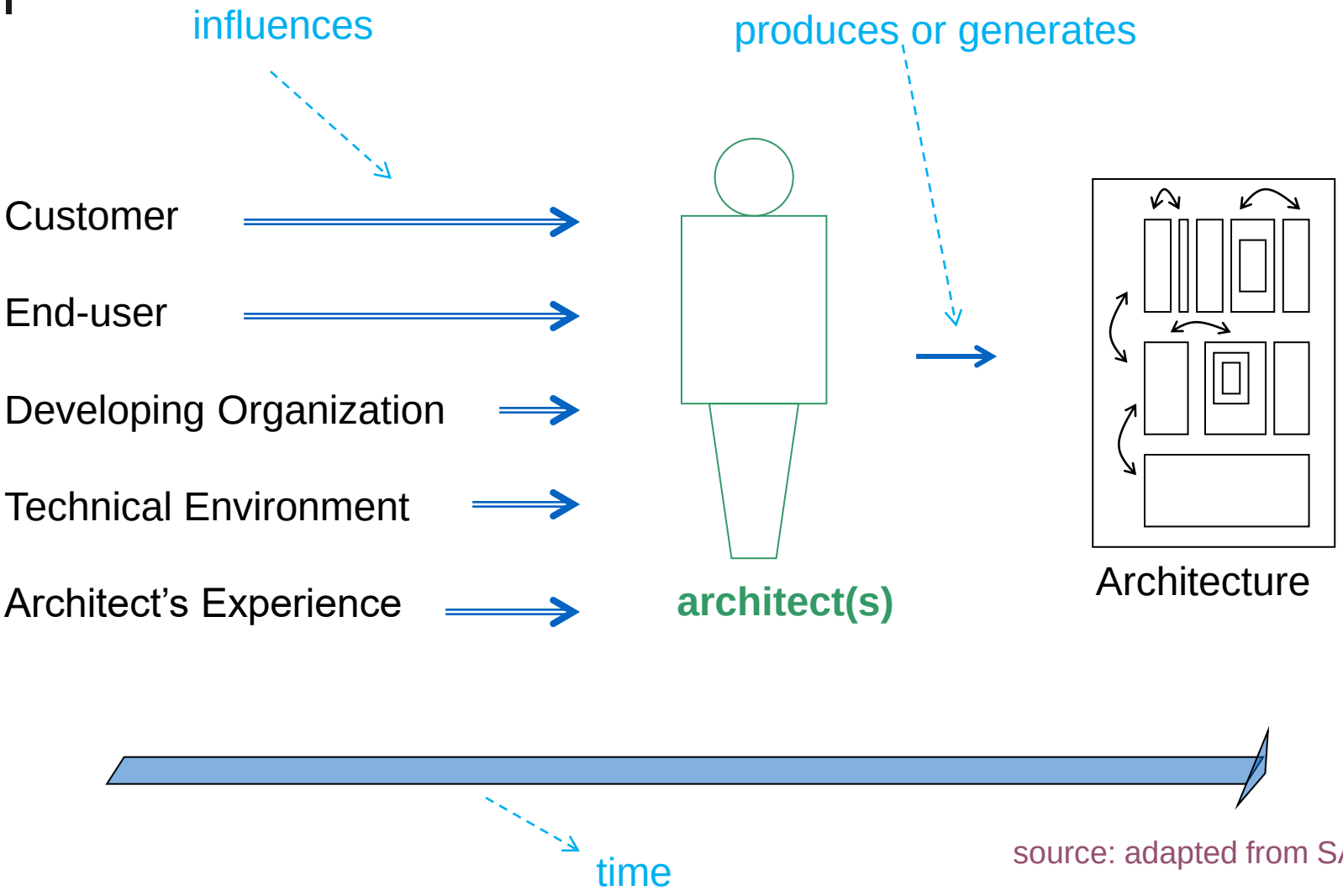
Organizational Imperatives

- **Pragmatics and reality of the business world**
  - Immediate, medium- and long-term business strategies
    - Asset reuse
    - Investment – asset building
  - Organizational structure
    - Small
    - Medium (e.g., Epic, Mathworks, …)
    - Large (e.g., HP, Intel, …)
    - Very Large (e.g., Amazon, Google, Oracle, PayPal, …)
    - *Contracting vs. in-house philosophy*

- **Large and medium organizations can impose constraints that affect directly architectural choices**
  - If an organization has expertise in data-flow architectural style, it can be a challenge to choose another such as data-centered

Software Architecture ⟷ **Organizational Structure**

Influences on the Architect(s) and Architecture

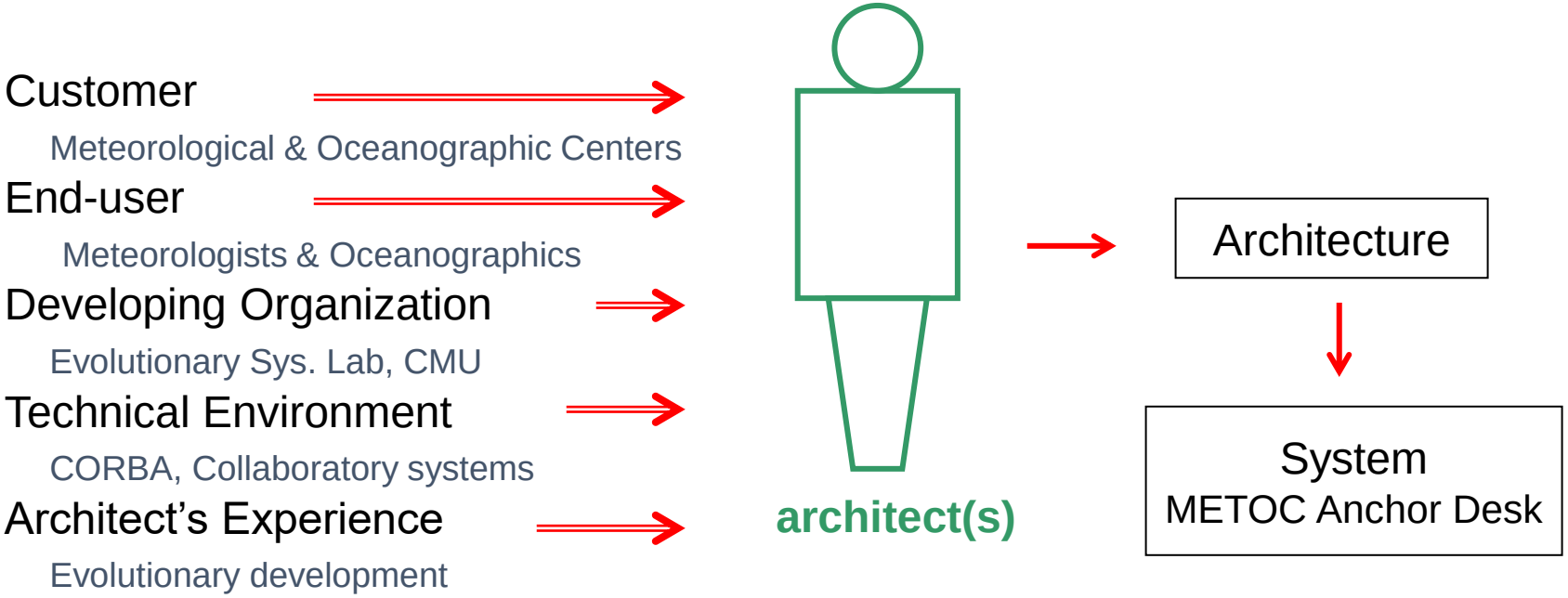


Influences on the Architect(s) and Architecture (cont.)

Example:

Meteorological and Oceanographic (METOC) Anchor Desk, Ch. 18, SAP

Web-based system developed from off-the-shelf components



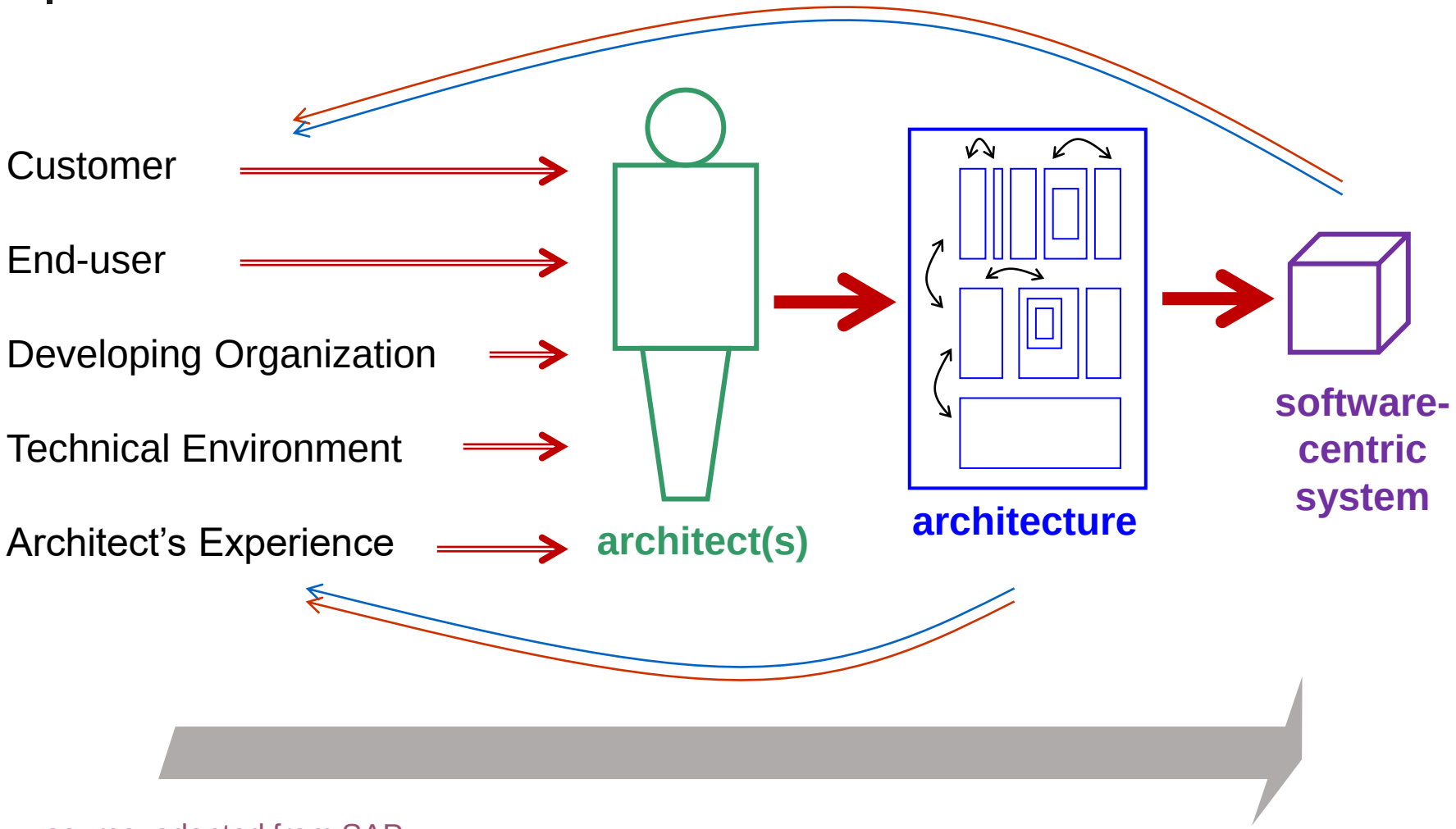
Architect's Skills

Architect's – likes and dislikes

- Education, Practice, and Training
  - **Methods**
  - **Processes**
  - **Tools**
- Experience plays an important role in selecting an architecture from many competing alternatives
  - **Successes & Failures**

- Architect's must be able to discover, understand, and formulate often contradictory stakeholders' goals and requirements
  - Technical skill
  - Organizational skill
  - Negotiation and diplomacy
  - Communication – preliminary design review
  - Broad domain knowledge
  - Common sense

The Architecture Business Cycle



source: adapted from SAP

SE Process and Architecture Business Cycle

- Some parts of software engineering process are intuitive – **magic boxes do not exist!**
  - Creating requirements from an idea (e.g., Point of Sale system)
  - Transforming requirements into an architectural design
- A philosophy
  - **Key focus**
    - Motivated workforce – attractive working environment, compensation, …
    - Competitiveness – tactics and strategies to gain market share
    - Quick time to market
  - **Supplementary focus – "just-good-enough"**
    - Integrability with other vendors
    - Reliability, configurability, etc.
    - Advancing Software Engineering at the expense of profit, …

Architecture driven activities for creating software/system are

- Creating the **business case** for the system
- **Understanding the requirements**
  - Use-cases, Facilitated Application Specification Techniques, …
  - Prototype – simulations and/or small-scale prototypes
  - Domain analysis – identify commonalities and variations with similar kinds of systems
- **Creating or selecting the architectures which have conceptual integrity**
  - Architectural styles/design patterns
  - Quality driven and use of prescribed methods and processes

Architecture-Centric Software Steps (cont.)

- Representing and communicating the architecture
  - Representations (texts, diagrams, formal languages, prototypes, …) should be accessible, informative, and unambiguous to many people with varied background
    - Architect(s) are responsible for behavioral, performance, and quality requirements – i.e., communication is essential
- Analyzing or evaluating the architecture
  - **Non runtime properties** – maintainability, …
  - **Runtime properties** – performance, behavior, communication, utilization, …
    - *Architecture Description Languages*
- Implementing software based on its prescribed architecture
  - Suitable infrastructure/environment – tools, standards, …
- Ensuring that the implementation conforms to the architecture
  - Rigorous supervision and inspection is needed

Choices of Software Architectures

- For a given technical set of requirements, we can expect as many architectures as there are architects – many factors influence the outcome!
- Per se, the ***"goodness"*** of an architecture is imprecise – a given architecture (client/server) is not inherently the worse or the best choice; it depends on a range of constraints
  - Client/server works well when there exists a large number of independent users
  - Client/server may be unsuitable for hard real-time applications (e.g., critical mission control)
- Nonetheless, **quality** of an architecture can be assessed.

Software Architecture

An architectural skeleton/structure

- specifies ***relationships*** & ***constraints*** among ***major software components***
  - a hierarchical structure of software components,
  - the ways components interact with one another, and
  - the structure of data
- Known *"design patterns"* are usually used (e.g., Observer also some refer to it as "Publisher-Subscriber")
- Some common patterns provide a basis for *general architectural designs* that can be specialized to the particulars of a software engineering problem

Good Software Architecture: Some Recommendations

- One – or a few architects (with one being the lead) – should be responsible for the architecture
- Architect (architecture team) should be highly competent – technically, organizationally, leadership, communication, …
- Architecture need to be well documented – use of standard notations is very important
- Architecture must be analyzed
  - Quantitative measures – performance, correctness, …
  - Qualitative properties – adaptability, integrability, …
- …

Summary

- Architecture Business Cycle (ABC) involves a variety of stakeholders and thus conflicting requirements, expectations, etc.
- Non-technical factors are as important if not more as compared with the technical factors
- The process starting from the stakeholders to architects, to architecture, to system, and back to stakeholders is an autocatalytic cycle
  - Autocatalytic cycle is a metaphor for a collection of mutually reinforcing relationships that is capable of sustained existence once each is established and a critical mass has been achieved.

References

- *Object-Oriented Analysis and Design with Applications, 3rd Edition, G. Booch, et. al. Addison Wesley, 2007*
- *Software Architecture in Practice, (SAP), Bass, L. Clements, P., and Kazman, R., Addison Wesley, SEI Series in Software Engineering, 1998*
- *Software Architecture in Practice, 2nd Edition, (SAP2), Bass, L. Clements, P., and Kazman, R., Addison Wesley, SEI Series in Software Engineering, 2003*
- *Software Architecture in Practice, 3rd Edition, (SAP3), Bass, L. Clements, P., and Kazman, R., Addison Wesley, SEI Series in Software Engineering, 2012*
- *Eclipse, http://www.eclipse.org/projects/, 2016*