ULS Ecosystem Design

Research Area: Design

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Today’s Problem

- Gap between state of art & practice
- Larger than in most other disciplines

Example: Security

- State of practice is still terrible overall

- Many big problems avoidable in principle

Tomorrow's Problem

- *State of the art itself deeply inadequate*
- "As software's complexity continues to rise, today's ... problems will become intractable unless fundamental breakthroughs are made in the science and technology of software design and development." *[President's Council of Advisors on Science and Technology, 07]*
- Tomorrow's problem is here today

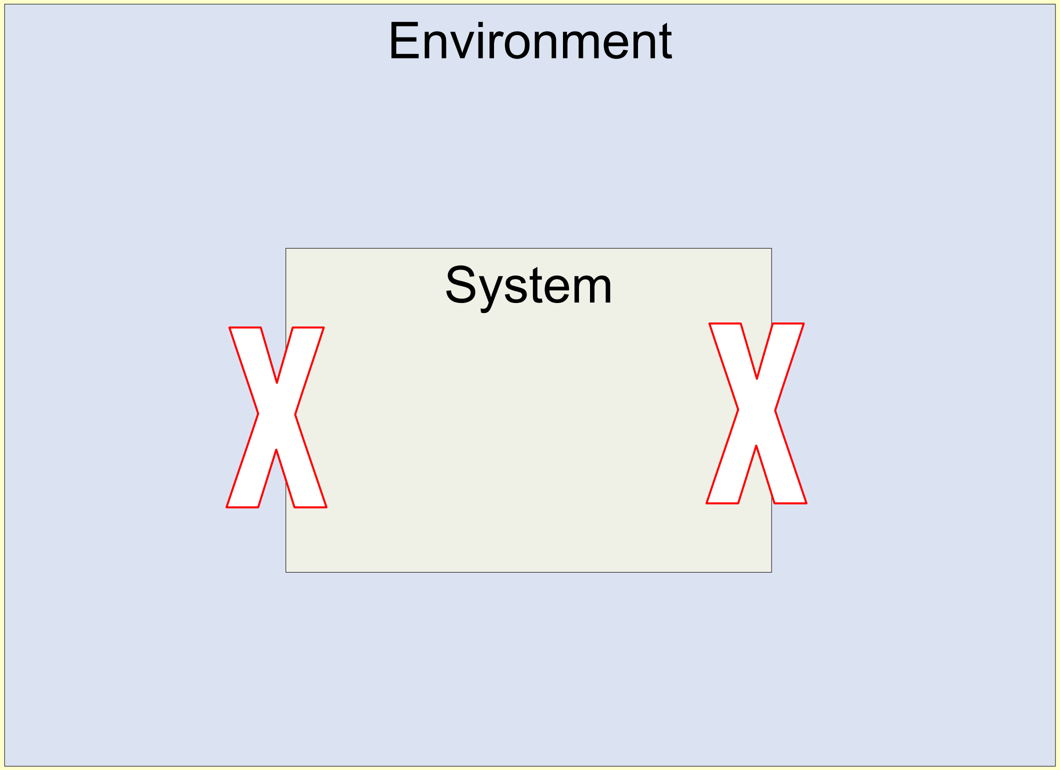
Today

- Define and lock ***requirements***
- Contract for ***development***
  - Partition system & design task: ***architecture***
  - Subcontract, implement, and integrate: ***code***
- Celebrate ***success***

Won’t Work for ULS Systems

- No one adequately understands requirements
- Conditions change (e.g., security/threat environment)
- No one really knows how to build what need to be built
- Complexity and uncertainty pose great challenges
- Once designed, resistant to change (e.g., IPv4 to IPv6)

Major Mismatches



Key Idea

The most critical property of a ULS system is its capacity to adapt to the change dynamics of (including the resolution of risk/uncertainty in) its environment. To be able to assure that given ULS systems have adequate adaptive capacity we need a new discipline of *ecosystem architecture.* Such a discipline will build on but transcend the discipline of software architecture. Economic considerations will play an important role in such a discipline.

Ecosystem Architecture

- Dynamic modeling & monitoring of complex & evolving environments
- Move from an emphasis on architecture of *software* to architecture of *socio-technical ecosystems* of software/system production, operation, use
- Design architecture for high adaptive capacity in the given environments
- Coupling of concerns across many levels of socio-technical ecosystem
- Example: security
  - What part(s) of ecosystem will respond to a threat or failure? Autonomic runtime layer? System operators? Software development team? An offensive countermeasures team? Impacts and coordination across multiple levels and administrative domains?

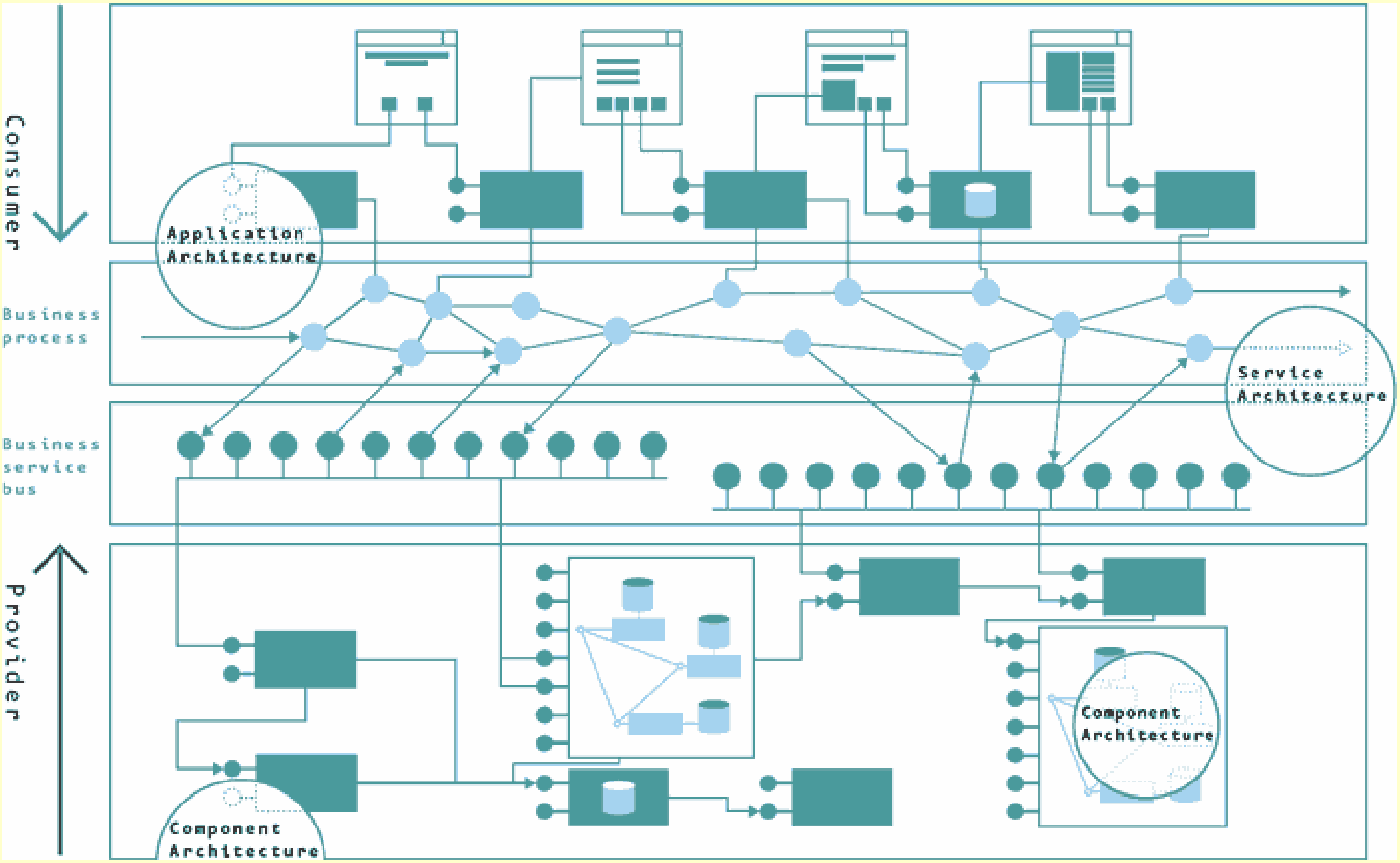
Initial Science Base

- Discipline of software design / architecture
- Structure and economics of modularity in design
- Reactive systems, e.g., for decision support
- Complex adaptive systems, biology
- Network science …

Today

- We're not even close
- Software architecture today
  - Focus on software artifacts and processes
  - Notations designed accordingly: e.g., UML
  - Not socio-technical ecosystem, environment
  - Box and arrow representations of software and hardware components, interconnections
  - Need to model/structure/analyze and manage dependences among key parameters across whole ecosystems

Today



Consumer
Provider
Application Architecture
Business process
Service Architecture
Business service bus
Component Architecture
Component Architecture

Tomorrow

- Architecture not about SW and HW components, per se, but about constraints that organize an adaptive optimization process across many levels of a system, including the SW and HW components
- Fundamental purpose of architecture is to ensure adaptive capacity commensurate with uncertainty & change dynamics of environment
- Adaptation dynamics in many dimensions, at many levels, at many time-scales
- Have to design ecosystem, including but not limited to SW/HW, *as a key step toward being able to get the SW/HW right*
- Key issues: decentralization & localization, “hiding” of adaptation needs, mechanisms, and dynamics; economic case for doing this

Structuring Concern Interdependences Across Ecosystem Levels is Critical

Contact

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- ULSSIS Center: http://ulssis.cs.virginia.edu
- ULS2 Workshop: http://ulssis.cs.virginia.edu/uls2, May 10-11, 2008, ICSE Leipzig, Germany