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Software Architecture: Perspectives on a Maturing Discipline

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ITALIA

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Mary Shaw & David Garlan (1996).
Software Architecture: Perspectives on an Emerging Discipline.
Upper Saddle River: Prentice-Hall.

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Outline

- Part 1
  - A brief history of software architecture
  - Software architecture in one easy lesson
    - What, who, how, when, why
- Break
- Part 2:
  - Architectural knowledge
  - Architectural decisions

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Part 1: Software Architecture

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A Brief History of Software Architecture (1/3)

- Before 1995:
  - 1969 NATO Conf
  - Conceptualization:
    - Brooks
    - Modules [Parnas]
  - Architecture = {Elements, Forms, Rationale} [Perry & Wolf]
  - ADLs – Components and Connectors
  - Styles [Shaw & Garlan]

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A Brief History of Software Architecture (2/3)

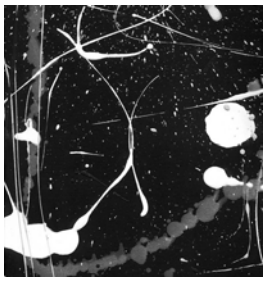
- 1995-2005
  - Architectural descriptions: views and beyond
  - Architectural methods
  - More ADLs
  - Many books (SEI, Clements and co.)
  - IEEE 1471-2000 on Architectural description
  - ISO RM-ODP (X.901-904)
  - Software Product Lines (SPL)
    - Variability

A Brief History of Software Architecture (3/3)

- 2005 – present
  - Broadening of the concepts (system, enterprise)
  - Quality of software architecture
  - Architectural decisions
  - Architectural knowledge
    - Capture, transfer
  - Architectural competence
    - Education
  - Aspects

Software Architecture

- What … is it ?
- Who … does it ?
- When … does it appear ?
- How … to do it ?
- Why … bothering at all ?



What is software architecture?

- Architecture = Structure ?
- Architecture = Design ?
- Architecture = Infrastructure ?
- System architecture vs. Software Architecture
- Enterprise Architecture ??

Software Architecture: A Definition

Software architecture encompasses the significant decisions about

- the organization of a software system,
- the selection of the structural elements and their interfaces by which the system is composed together with their behavior as specified in the collaboration among those elements,
- the composition of these elements into progressively larger subsystems,

Grady Booch, Philippe Kruchten, Rich Reitman, Kurt Bittner; Rational, circa 1995
(derived from Mary Shaw)

Software Architecture (cont.)

- the architectural style that guides this organization, these elements and their interfaces, their collaborations, and their composition.

  Software architecture is not only concerned with structure and behavior, but also with usage, functionality, performance, resilience, reuse, comprehensibility, economic and technological constraints and tradeoffs, and aesthetics.

RUP 1998

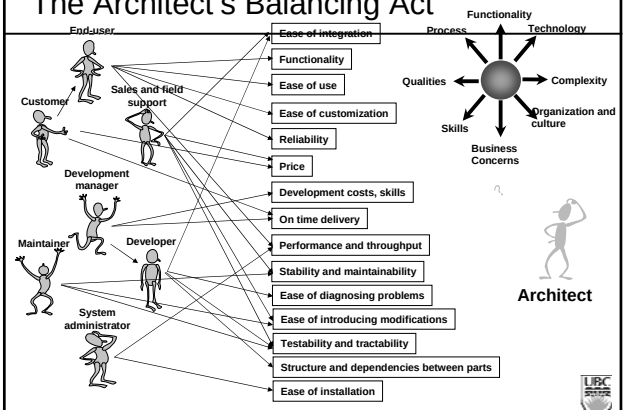
So software architecture…

- … is a part of Design
  But not all design is architecture
  … *which part of design, then?*
- … includes Structure, and much more
  Behaviour, style, tools & language
- … includes Infrastructure, and much more
- … is part of System architecture

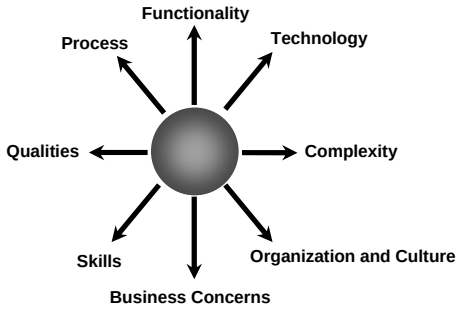
All systems have an architecture

- How much effort should you put into it varies greatly
- 75%: architecture is implicit
  - Choice of technology, platform
  - Need to understand the architecture
- Novel systems:
  - Much more effort in creating and validating an architecture
- Key drivers are mostly non-functional:
  - Capacity, performance, availability, evolvability, security, …

The Architect's Balancing Act



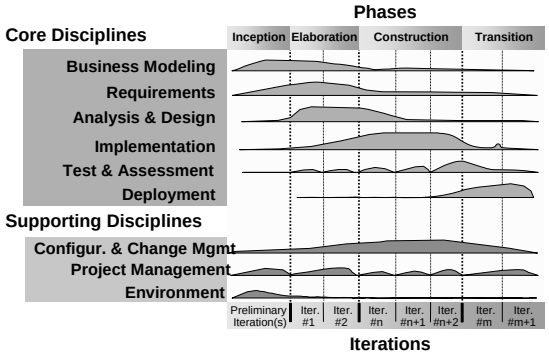
Tradeoffs Between Forces



Architecture is about making decisions

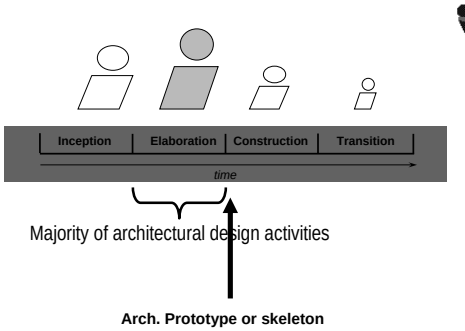
The life of a software architect is a long (and sometimes painful) succession of suboptimal decisions made partly in the dark.

Rational Unified Process® (RUP®)



Source: IBM, 2003

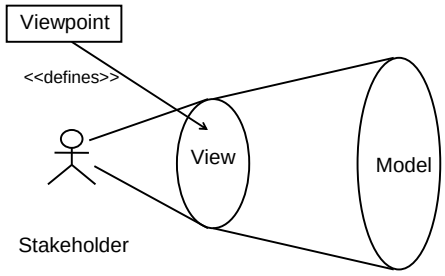
Architectural Effort During the Lifecycle



Representation of architecture

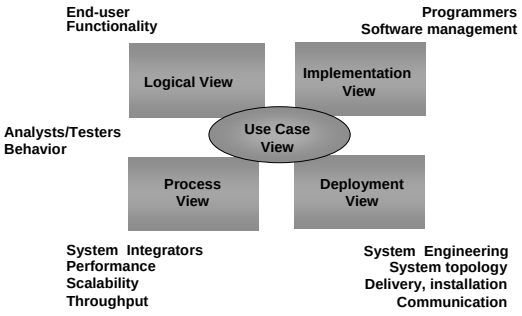
- Software Architecture Document
  - Multiple views
- Architectural prototype, or skeleton
  - Result of early iteration
    - RUP's elaboration phase
  - Or almost "ready made" (out of the box)

Of Views, Viewpoints and Models



Views are projections of a model for a particular stakeholder

RUP's 4+1 Views



Source: Kruchten 1995

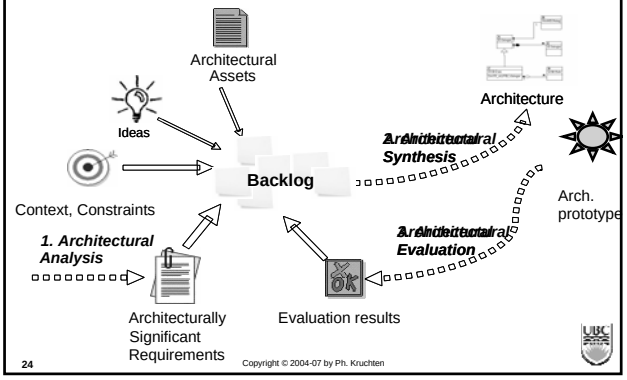
Architectural methods

Source: Hofmeister et al 2005

- SEI: SAAM, ATAM
  - Clements, Bass, Kazman, Barbacci
- Philips: BAPO + CAFCR
  - Obbink, America, …
- Siemens: S4V
  - Nord, Hofmeister, …
- Nokia: ASC
  - Ran…
- IBM Rational: RUP
  - Kruchten, Booch, Wood, Eeles, …

General Workflow

Source: Hofmeister et al 2005



VRAPS: Dealing with hidden realities

- Vision
  - Provide a coherent, compelling picture of the future to all major stakeholders (in and out)
- Rhythm
  - Iteration, "tempo", keep things moving, not analysis-paralysis
- Anticipation
  - Link to risk mitigation: business risk, long-term
- Partnering
  - Cooperation, teamwork, get buy-in of all parties
- Simplification
  - Both at the design level and at the organization level

Source: Dikel et al

Benefits of an Architectural Focus

- Support Project & Product Management
  - Partitioning between teams (large system)
  - Buy vs. build: contracting, outsourcing
  - Reuse, product line
- Communication
  - Between all stakeholders, across teams
- Stability, predictability
- Separate:
  - Long-term, strategic, global decisions
  - Short-term, tactical, local decisions
- Documentation

Software Architecture: A Basis…

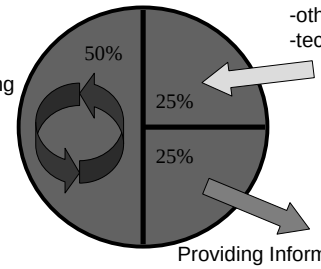
- for Component-base development
- for a reuse policy and strategy
- for Software Product Line
- for COTS-Based development

Software Architecture and Agile Methods

- XP: Metaphor
- Scrum, DSDM, Lean, FDD
- *"No BUFD !", "YAGNI !"*
- They assume relatively stable architecture
  - Go straight into RUP construction phase
- Architecture will not emerge by simple successions of "refactoring"
- Complex, large or novel systems may "hit a wall"

What do architects actually do?

Architecting:
-design
-validation
-prototyping
-documenting
-etc….



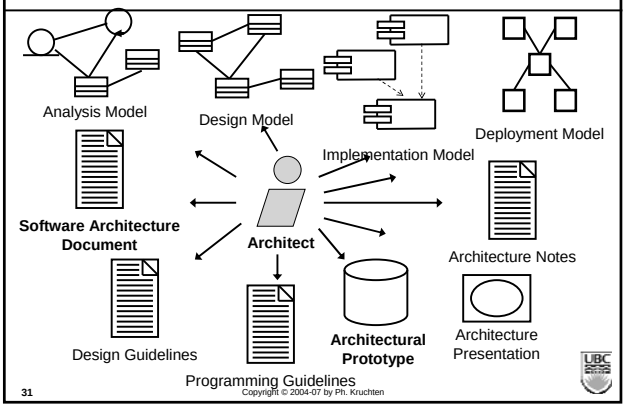
Getting input:
-user, requirement
-other architecture
-technology

Providing Information
-communicating architecture
-assisting other stakeholders

Software Architect (or Team) Charter

- Defining the architecture of the software
- Maintaining the architectural integrity of the software
- Assessing technical risks related to the software design
- Proposing the order and contents of the successive iterations
- Consulting services
- Assisting marketing for future product definition
- Facilitating communications between project teams

Architectural Artifacts



Research on software architecture

- From Architectural Design
  to Architectural Design Decisions
- Architectural Knowledge =
  Architectural Design + Architectural Decisions
- Decisions = making a binding choice:
  - Relationships
  - Rationale
  - Tacit knowledge

More research directions

- ADL = Architecture Description Languages
- ADN = Architectural Design Notation
- SPL: Software Product Lines
  - A common architecture, several products
- Model Driven Architecture / Design
- Service-Oriented Architecture
- Aspect-oriented architecture

Summary

- Architecture is…
  - a subset of design
  - more than just structure
  - the place of resolution of major tensions
  - the concern of many stakeholders

Summary

- All systems have an architecture
- Project manager understands the role of architecture and exploits it:
  - to define an organization
  - to drive early phases (inception, elaboration)
  - to mitigate most dramatic technical risks
  - to define a rhythm for iterative development
  - to articulate reuse
  - to instill a common culture
- Architecture team, for large projects, or a family
- Project manager <–> Chief architect

Break

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Part 2: Architectural Knowledge and Design Decisions

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Software Architecture in RUP

Software architecture encompasses the significant decisions about

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Software Architecture in RUP (cont.)

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Architectural decisions as 1st class elements

- Software architecture encompasses the set of significant decisions about the organization of a software system

  …

- Design = Making choices
  - Leonardo da Vinci : disegno
    Giambattista Vico : ingenio
  - in French: un Dessin avec un Dessein
    = A drawing with an intent

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Getting at the architecture

- Architecture document
  - Views, UML, text, PowerPoint slides, xP's Metaphors
- Reverse engineering

- But the decisions only partially emerge
- Part of architectural knowledge is lost

Architectural Knowledge =
Design Decisions + Design

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Modeling the decisions

- Not the design
- But the decisions

For what purpose?

- Rationale
- What if
- Cross-cutting concerns
- Political and organizational issues

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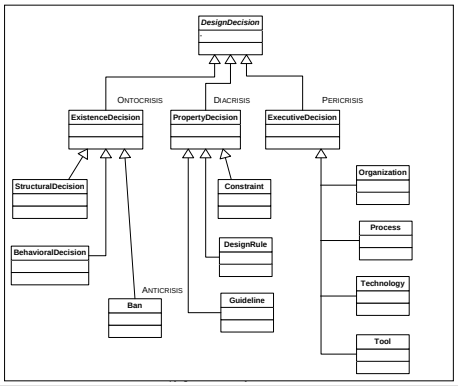
Types of architectural design decisions

- Ontocrises: existential decisions
  - state what element will exist in the design
  - also anticrises (ban, things that will not exist)
- Diacrises: property decisions
  - associate predicate to set of elements
  - Cross cutting concerns, “aspects”
- Pericrises: executive decisions
  - constrain the above, the organization, etc.

Taxonomy of decisions



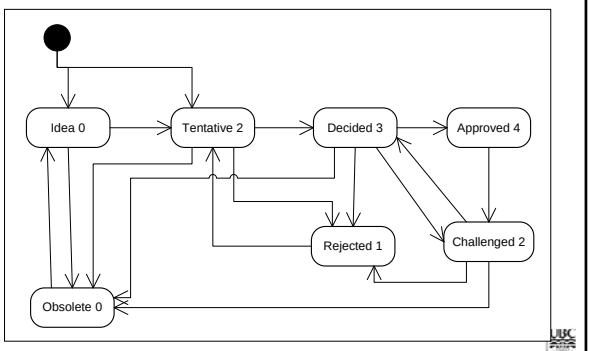
Attributes of a decision

- Epitome Text
- Rationale Text or Pointer
- Scope Text
- State Enumeration
- History List of (time stamp + author + change)
- Cost Value
- Risk Exposure level

Relationship between decisions

- Constrains
- Forbids
- Enables
- Subsumes
- Conflicts with
- Overrides
- Comprises (is made of)
- Is bound to
- Is an alternative to
- Is related too
- Traces to
- Does not comply with

States of decision



What is the use of a decision graph

- Rationale
  - Connection between requirements, defect and implementation
- Support for review
  - Completeness, consistency
  - Incremental reviews
- Support for evolution
  - Change analysis, “what if”
- Support for reuse, for learning the architectural process itself, for extracting patterns of decisions

Capturing design decisions

- Design Rationale support systems failed because of overhead of capture
  - not enough immediate value, no incentive to capture
  - tedious process, static diagrams
  - QOC, DRL, InfoRAT, IBIS etc.
- Automating capture with daemons (agents)
  - Instrument source of decision:
    - Design tool
    - Requirement management tool
    - Defect tracking tool
    - Configuration and change management tool
    - Management tool (task allocation, issue/action items)

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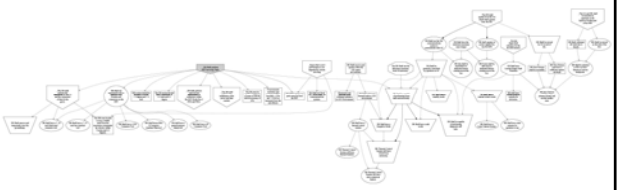
Experiment: Spar Aerospace Dexterous Robot



- Dexterous Robot = arm used to fix the Hubble telescope
- Michael Trauttmansdorff & Nicolas Kruchten
- MySQL Database, SVG + GraphViz

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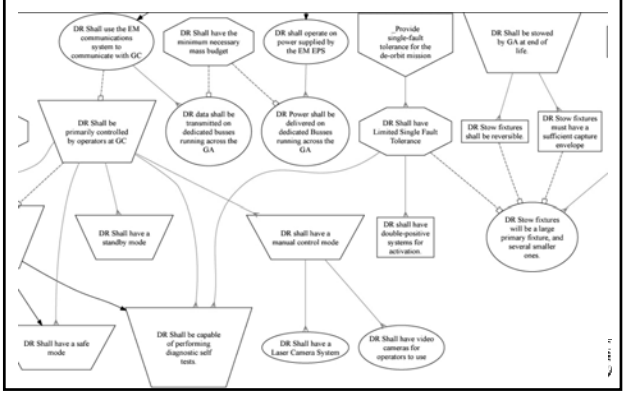
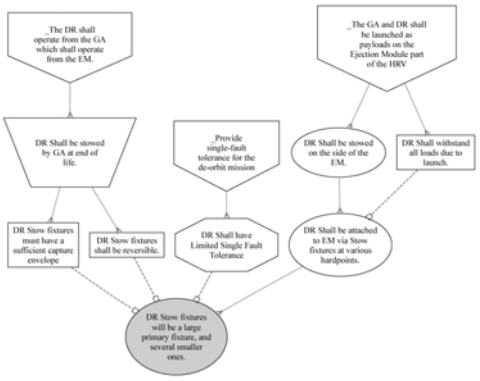
Fragment, enlarged



Extraction, around Stow Fixture



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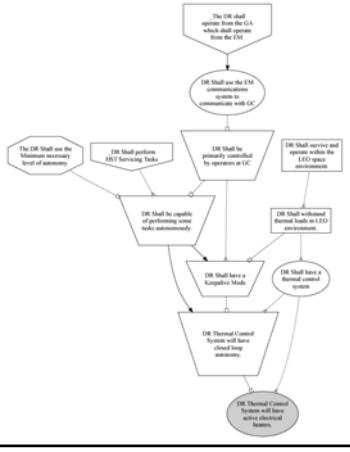
Heaters



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Difficulties

- Design rationale: research peaked in the late 1997
  - hard to do consistently; tedious capture
  - no immediate benefits for architects
  - not very useful for software
- Focus shifts
  - from Rationale and Decision Support,
  - to Decision and connections between decisions

  (rationale becomes secondary)

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Software architecture?

- May apply to wider area than just software architecture
- Systems engineering

Future work

- Refine model
  - Develop more case studies
    - Raytheon: air traffic control,
    - CapitalOne: Banking…
    - Genomics tools at BC Genome science corporation
  - Develop mathematical model, find patterns
- Investigate visualization
  - Icons, arrows, arrowhead, color, position
  - Automatic layout
- Design decision capture mechanism
  - Aim at Eclipse platform: EMF and Rational tool suite

Thanks

- Hans van Vliet and Patricia Lago from the Vrije Universiteit in Amsterdam
- Davide Falessi, U. di Roma Tor Vergata
- Larix Lee (Master student at UBC)
- Shark community (Sharing Architectural Knowledge)
- IBM Canada

Resources

Web sites, portals
- SEI's Software Architecture for Software-Intensive Systems http://www.sei.cmu.edu/architecture/
- The Gaudí System Architecting page http://www.gaudisite.nl/
- The Bredemeyer Architecture page http://www.bredemeyer.com/
- Software Product Lines http://softwareproductlines.com/
- SoftwareArchitectures.com http://www.softwarearchitectures.com
- Grady Booch's Handbook of Software Architecture www.booch.com/architecture/index.jsp

Conferences
- WICSA http://www.softwarearchitectureportal.org/WICSA/conferences/
- EWSA http://www.arch-ware.org/ewsa
- SPLC http://softwareproductlines.com/

Associations and working groups
- IFIP WG 2.10 Software Architecture
- http://www.softwarearchitectureportal.org
- WWISA World-wide Institute of Software Architects http://www.wwisa.org
- IASA International Association of Software Architects http://www.iasarchitects.org

Research and Education
- Nenad Medvidovic, at the University of Southern California: http://sunset.usc.edu/research/software_architecture/index.html
- Gert Florijn, at the Software Engineering Research Centre in the Netherlands: http://www.serc.nl/people/florijn/interests/arch.html

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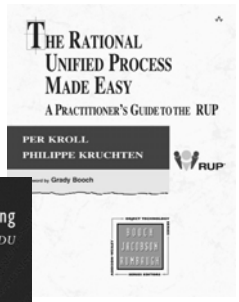
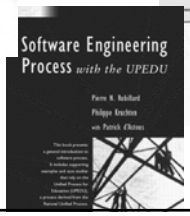
Shameless self-promotion





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