BITS Pilani

Pilani|Dubai|Goa|Hyderabad

SS ZG653: Software Architecture

Lecture 1: Introduction

Instructor: Prof. Santonu Sarkar

Jan 10, 2015

About the Course

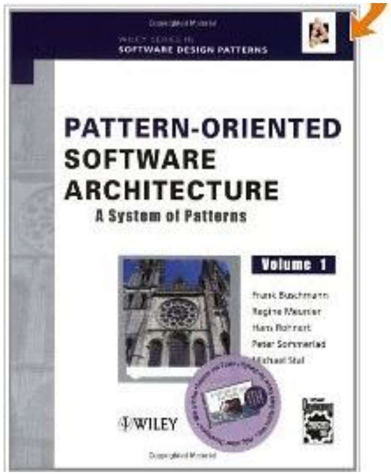
- To study software architecture (we will simply call architecture in this context)
  - What is the abstraction of the software, and how to create, and how to represent
  - What are the relationships between various entities
  - How architectural principles are used during software system analysis and design.
- To study about the role of architecture patterns in software design
- To study about the applicability of design patterns in software design

Course Objective

- To have sound understanding of software architecture
  - and remove misconceptions
  - the current state of the discipline of Software Architecture
  - Know the way in which architecture can impact design
  - Know various architectural styles, views
  - Importance of nonfunctional requirements, or quality attributes of a system
- Apply the concept
  - Design new systems in principled ways, using well-understood architectural paradigms
  - Present concrete examples of actual system architectures that can serve as model for new designs
- Evaluate
  - Evaluate designs of existing software systems from an architecture perspective

Study Material

- Text Books
  - Len Bass et al, Software Architecture in Practice, Pearson, Third (or Second) Edition, ISBN 9789332502307
  - F. Buschmann et al, Pattern Oriented Software Architecture – Volume1, Wiley, 1996



Study Material contd…

- References
  - R. N. Taylor et al, Software Architecture: Foundations, Theory, and Practice, John Wiley & Sons, 2009
  - Mary Shaw & David Garlan, Software Architecture – Perspectives on an Emerging Discipline, PHI, 1996.
  - Stephen T. Albin, The Art of Software Architecture, Wiley Dreamtech, 2003.
  - Gamma, E. et. Al. Design Patterns: Elements of Reusable Object Oriented Software, Addison Wesley, 1995

Teaching and Evaluation

- Lectures: 16 + 2 Review
- Exams: 2
  - Midterm: 35%
  - Final: 50%
- Quizzes: 15%

- Midterm Exam
  - Closed Book and notes
- Final Exam
  - Open Book and notes
- The exam solutions/ answers are expected to be of Masters Level with crisp, to-the-point, concise, proper, neat and readable presentation

Detailed Schedule

Lecture#	Topics
1	Software Architecture and its Importance
2	Many perspectives of Software Architecture Introducing Quality Attributes
3-5	Role a few quality attributes in details – Architectural Tactics • Availability, Interoperability, Modifiability • Performance, Security, Testability
6-7	Object-oriented concepts and UML • Classes, Objects, Encapsulation, Polymorphism, Inheritance and their representation in UML • Class diagram, Sequence diagram, Class Responsibility and Collaboration (CRC) Cards
8	Styles and Patterns • Concept, Categories and descriptions • Architecture style - Layering
Review Session	
Syllabus for Mid-Semester Test (Closed Book) : Topics covered in S. No. 1 to 8	

Detailed Schedule contd…

Lecture#	Topics
10-12	Architecture Style: Blackboard style, Pipe and Filter style Distributed System Style: Broker Architecture Interactive System Style Model-View-Controller Adaptable System Microkernel, Reflection
13-17	Design Pattern • Components of a typical design pattern, and different categories of design patterns Behavioral Category • Iterator Pattern Behavioral Category • Observer, Strategy, Visitor, Command Structural Category • Adapter, Decorator, Composite, Proxy Creational Category • Factory Pattern, Factory Method, Singleton
Review Session	
Syllabus for Comprehensive Examination (Open Book): All topics given in the Plan.	

SOFTWARE ARCHITECTURE

Informally what is meant by (Software) Architecture

- Essentially a blueprint of a software system that helps **stakeholders** to understand how the system would be once it is implemented
- What's should be there in this blueprint?
  - A description at a higher level of abstraction than objects and lines of codes

  So that

  - Stakeholders understand and reason about without getting lost into a sea of details

Who are Stakeholders?

A complex software has multiple stakeholders who expect certain features of the software

Stakeholder	Area of Concern
Chief Technologist	• Does it adhere to organization standards ?
Database Designer	• What information to be stored, where, how, access mechanism??? • Information security issues?
Application Development team	• How do I implement a complex scenario? • How should I organize my code? • How do I plan for division of work?
Users/Customers	• Does it perform as per my requirement? • What about the cost/budget? • Scalability, performance and reliability of the system? • How easy it is to use? • Is it always available?
Infrastructure Manager	• Performance and scalability • Idea of system & network usage • Indication of hardware and software cost, scalability, deployment location • Safety and security consideration • Is it fault tolerant- crash recovery & backup
Release & Configuration Manager	• Build strategy • Code management, version control, code organization
System Maintainer	• How do I replace of a subsystem with minimal impact ? • How fast can I diagnosis of faults and failures and how quickly I can recover?

Why Architecture needs to be described?

Any Large Software Corporation

- ❑ Hundreds of concurrent projects being executed
  - ➢ 10-100 team size
- ❑ Projects capture requirements, there are architects, and large Development teams
- ❑ Architect start with requirements team & handover to Development teams

- Each stakeholder has his own interpretation of the systems
  - Sometimes no understanding at all
  - Architect is the middleman who co-ordinates with these stakeholders
- How will everyone be convinced that his expectations from the system will be satisfied?
- Even when the architect has created the solution blueprint, how does she handover the solution to the developers?
- How do the developers build and ensure critical aspects of the system?
- Misunderstanding leads to incorrect implementation
  - Leads to 10 times more effort to fix at a later stage

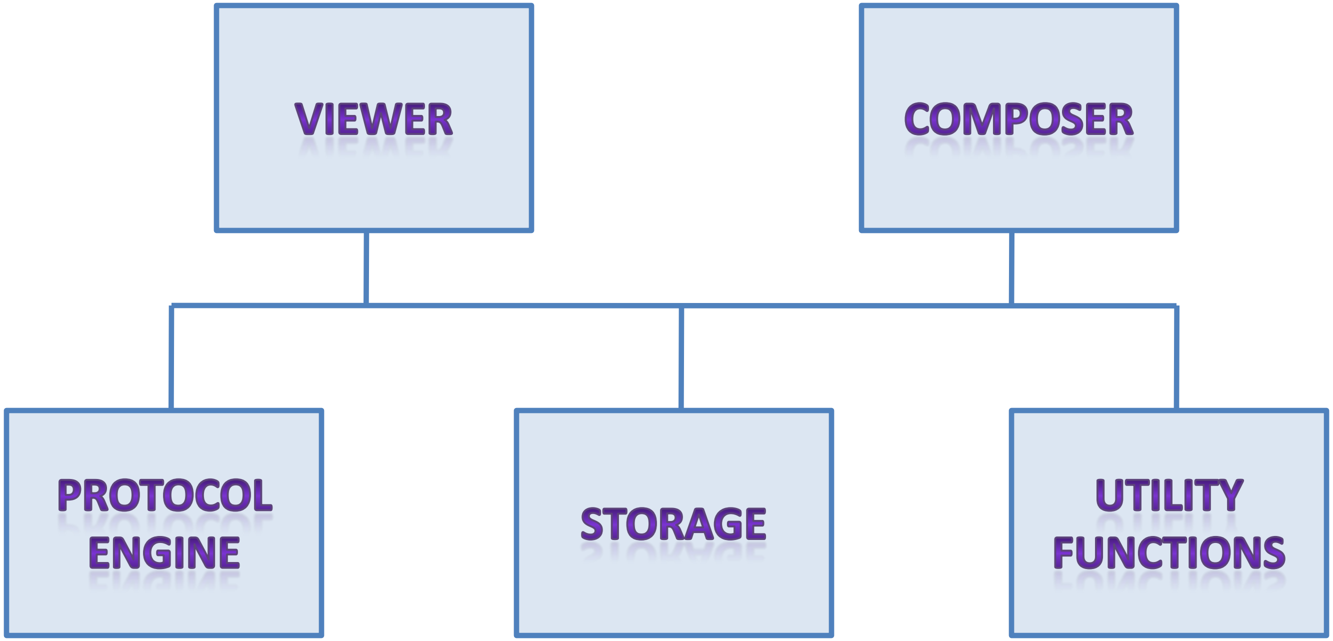
Software Architecture Definition

- No unique definition though similar…
  - (look at http://www.sei.cmu.edu/architecture/start/glossary/classicdefs.cfm)
- .. "**structure** or structures of the system, which comprise **software elements**, the **externally visible properties** of those elements, and the **relationships** among them" (Bass, Clements and Kazman, Software Architecture in Practice, 2nd edition)
- "description of elements from which systems are built, **interactions** among those elements, **patterns** that guide their **composition**, and **constraints** on these patterns. In general, a particular system is defined in terms of a collection of **components** and interactions among these components"

  Shaw and Garlan "*Software Architecture: Perspectives on an Emerging Disciplines*"
- "description of the **subsystems** and **components** of a software system and the **relationship** between them. Subsystems and components are typically specified in different **views** to show the relevant **functional** and **nonfunctional** properties of a software system"

  F. Buschmann et al, Pattern Oriented Software Architecture

Is this Architecture



What we understand

- The system has 5 elements
- They are interconnected
- One is on the top of another

Typically we describe architecture as a collection of diagrams like this

What’s Ambiguous?

- Visible responsibilities
  - What do they do?
  - How does their function relate to the system
  - How have these elements been derived, is there any overlap?
- Are these processes, or programs
  - How do they interact when the software executes
  - Are they distributed?
- How are they deployed on a hardware
- What information does the system process?

What’s Ambiguous?

- Significance of connections
  - Signify control or data, invoke each other, synchronization
  - Mechanism of communications
- Significance of layout
  - Does level shown signify anything
  - Was the type of drawing due to space constraint

What should Architecture description have?

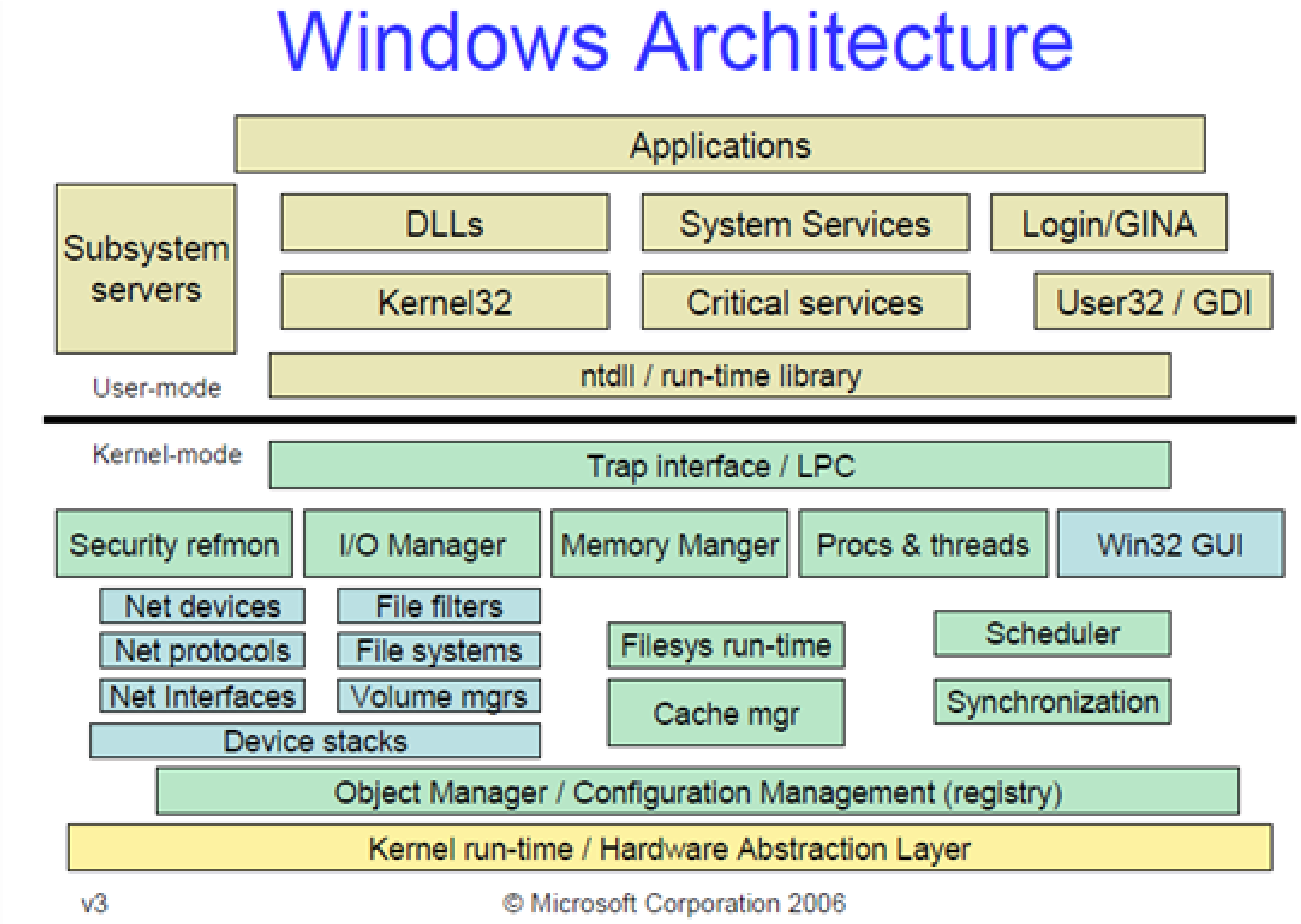
- A structure describing
  - Modules
    - Services offered by each module
    - and their interactions- to achieve the functionality
  - Information/data modeling
  - Achieving quality attributes
  - Processes and tasks that execute the software
  - Deployment onto hardware
  - Development plan

What should Architecture description have?......

- A behavioral description
  - describing how the structural elements execute "important" and "critical" scenarios
    - E.g. how does the system authenticates a mobile user
    - How does the system processes 1 TB of data in a day
    - How does it stream video uninterruptedly during peak load
  - These scenarios are mainly to implement various quality attributes

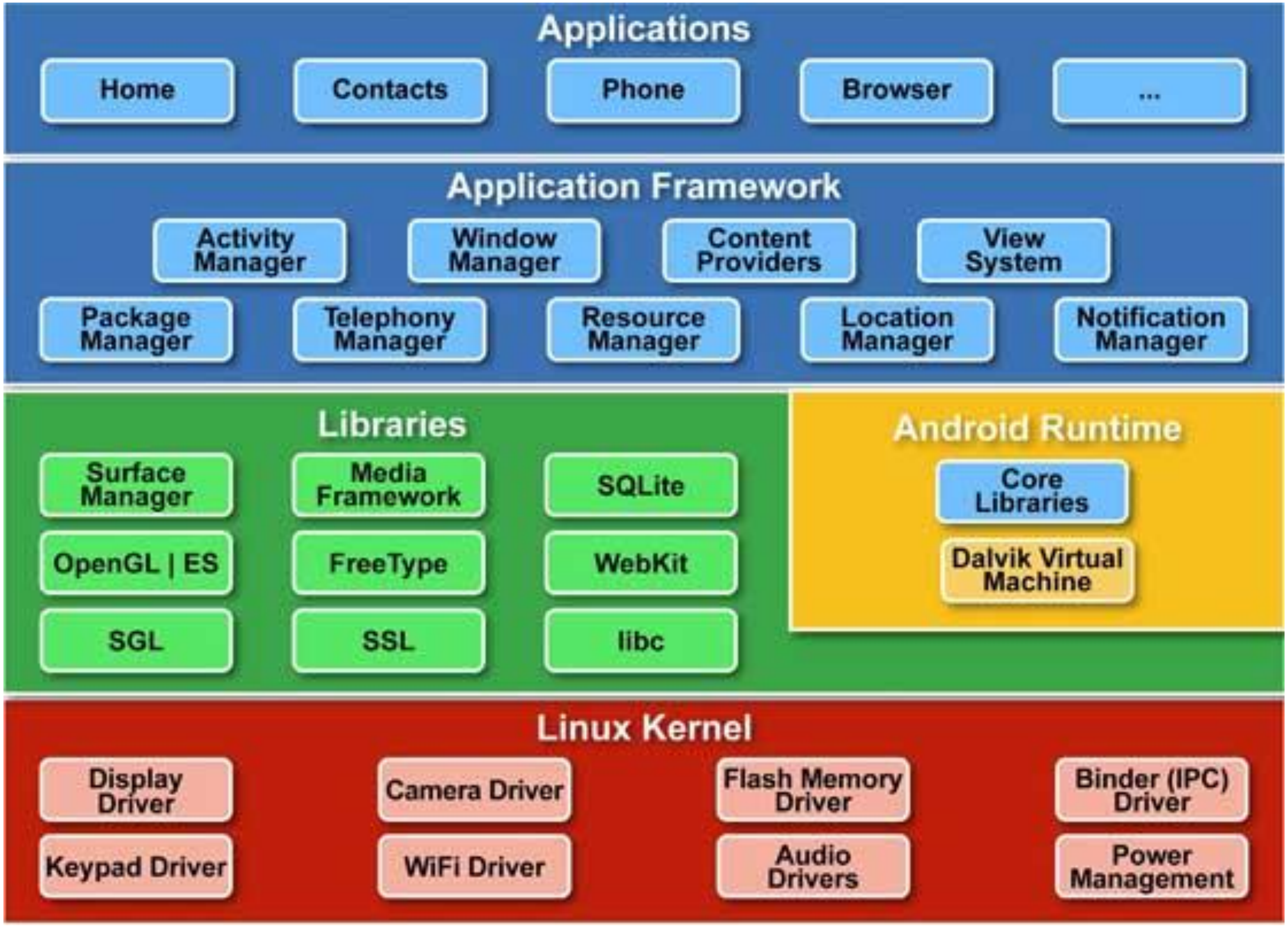
Architecture of Windows

https://http://blogs.msdn.com/b/hanybarakat/archive/2007/02/25/deeper-into-windows-architecture.aspx



Architecture of Android

http://www.techotopia.com/index.php/An_Overview_of_the_Android_Architecture



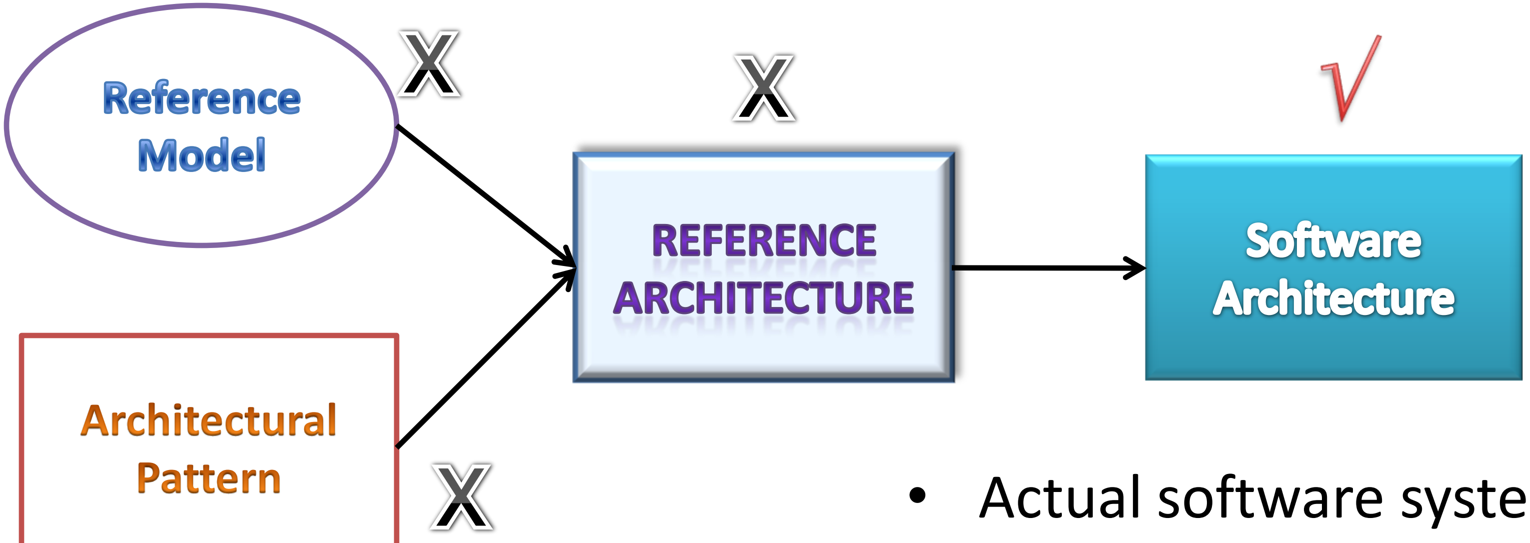
Architecture Styles

- Architecture style first proposed by Shaw and Garlan– synonymous to “architecture pattern”
  - A set of element types (what the element does- data store, compute linear regression function)
  - A set of interaction types (function call, publish-subscribe)
  - Topology indicating interactions and interaction types
  - Constraints
  - Also known as architectural pattern
- We shall cover some of these patterns in details

Reference Model and Reference Architecture

- A reference model
  - Decomposes the functionality into a set of smaller units
  - How they interact and share data
  - These units co-operatively implement the total functionality
- A reference architecture
  - Derived from the reference model
  - Concrete software elements, mapped to the units of the reference model, that implement the functionality

Inter-relationships



- Not architecture by itself!!

- Actual software system blueprint derived from requirement
- Contains design decisions
- Describes how it is deployed
- Addresses Quality of Service concerns

Benefits of Software Architecture

1. Every stakeholder should understand "unambiguously" what the blueprint is
   - Standard approach, vocabulary, output
   - Common language for communication

2. Streamlining work assignments for multiple teams
   - Avoiding information loss, enforcing traceability

3. Design decisions are made early
   - Quicker to evaluate these decisions and correct it rather than discovering it later (10 – 100 times more costly)
   - Early analysis of QoS and evaluation of architecture
   - Early analysis of meeting quality requirements and compromise between different QoS requirements
   - Early prototyping of important aspects quickly
   - More accurate cost and schedule estimation

4. Improve speed of development
   - Reuse
     - Helps in building a large product line faster by sharing common architecture
     - From one implementation to another similar implementation
   - Based on the architecture, one can quickly decide build-vs –use external components
   - Tool that can automate part of development, testing

Views and Architectural Structure

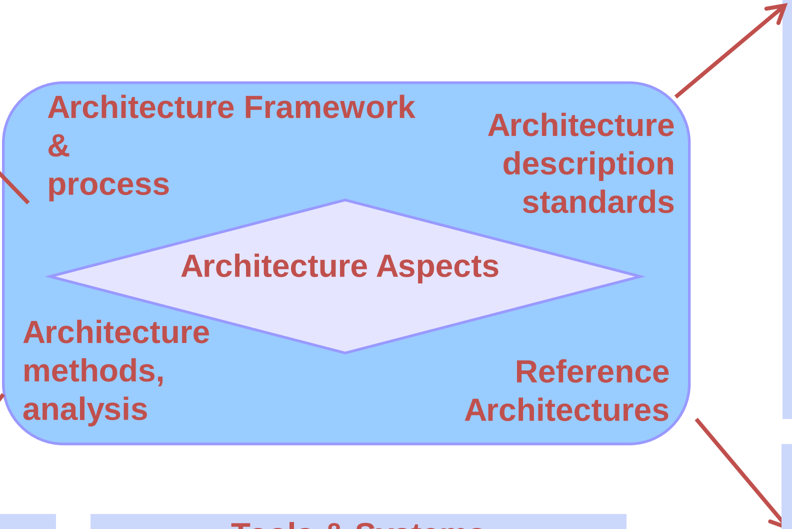
- Since architecture serves as a vehicle for communication among stakeholders
  - And each stakeholder is interested about different aspects of the system
  - It is too complex to describe, understand and analyze the architecture using one common vocabulary for all stakeholders
    - Essentially it needs to be described in a multi-dimensional manner
- View based approach
  - Each view represents certain architectural aspects of the system, created for a stakeholder
  - All the views combined together form the consistent whole
- A Structure is the underlying part of a view- essentially the set of elements, and their properties
  - A view corresponding to a structure is created by using these elements and their inter-relationships

Three Structures will be covered

- Module Structure
  - How is the system to be structured as a set of code units (modules)?
- Component-and-connector structures
  - How is the system to be structured as a set of elements that have runtime behavior (components) and interactions (connectors)
  - What are major executing components and how do they interact
- Allocation structures
  - How is the system to relate to non-software structures in it's environment (CPU or cluster of CPUs, File Systems, Networks, Development Teams …)

In Bits and Pieces (Unfortunately)

TOGAF, Zachmann
SEI ATAM, SAAM
ISO 10746 RM-ODP
IBM enterprise architecture standard
C4ISR
US Treasury Architecture Development process



Architecture Framework & process

Architecture description standards

Architecture Aspects

Architecture methods, analysis

Reference Architectures

Architecture description standards
- ISO 10746 RM-ODP
- IEEE 1471,
- RUP 4+1 views
- ISO/IEC 9126 – software quality

Architecture modeling
- UML and MDA EDOC
- Architecture description language

Behavior modeling
- BPML, BPELWS, Statechart, CSP, Petri-net

Network Queuing theory, MVA
Markov modeling for availability analysis
Formal verification techniques
Rule based system for applying architecture heuristics
Engineering best practices

Tools & Systems

* Many open source tools – Acme, XADL
IBM Rational System Architect
Many Quality of service analysis tools

Patterns
- Industry specific
- Insurance Reference Architecture: IAA
- IBM e-Business Architecture patterns

Architecture Style

Thank You