Software Engineering Aspects of Software Radio

Research Review on Network and Operations Management Technologies

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Outline

- Short Tutorial
  - What is Digital Signal Processing?
  - What is a Software Radio?
  - Software Radio Architecture
  - What is a Software Defined Radio?
  - Software Defined Radio Architecture
- UML-Based Modeling Process
  - Characteristics of the modeling process
  - Our objectives
  - What is UML?
  - From design to implementation
- Current Projects/Collaborations

Highlights of the wireless history

R. A. Fessenden, 1900

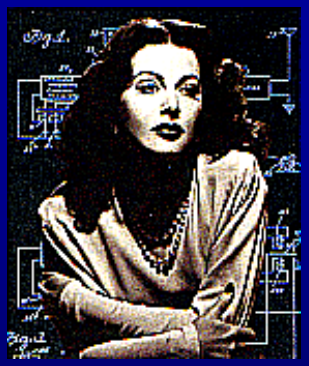
Radio-Telephone

M. Barbeau, 1962
Sending morse code

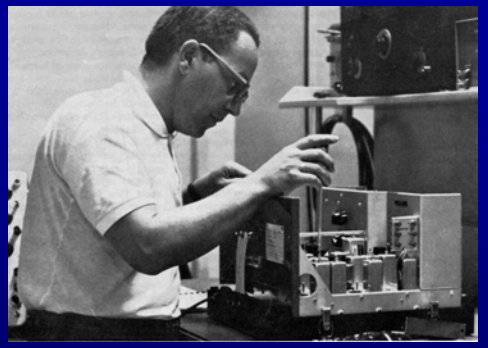
J. Mitola III, 1991

Software radio

G. Marconi, 1895
wireless telegraphy



H. Lamarr and G. Antheil, 1942
frequency-switching

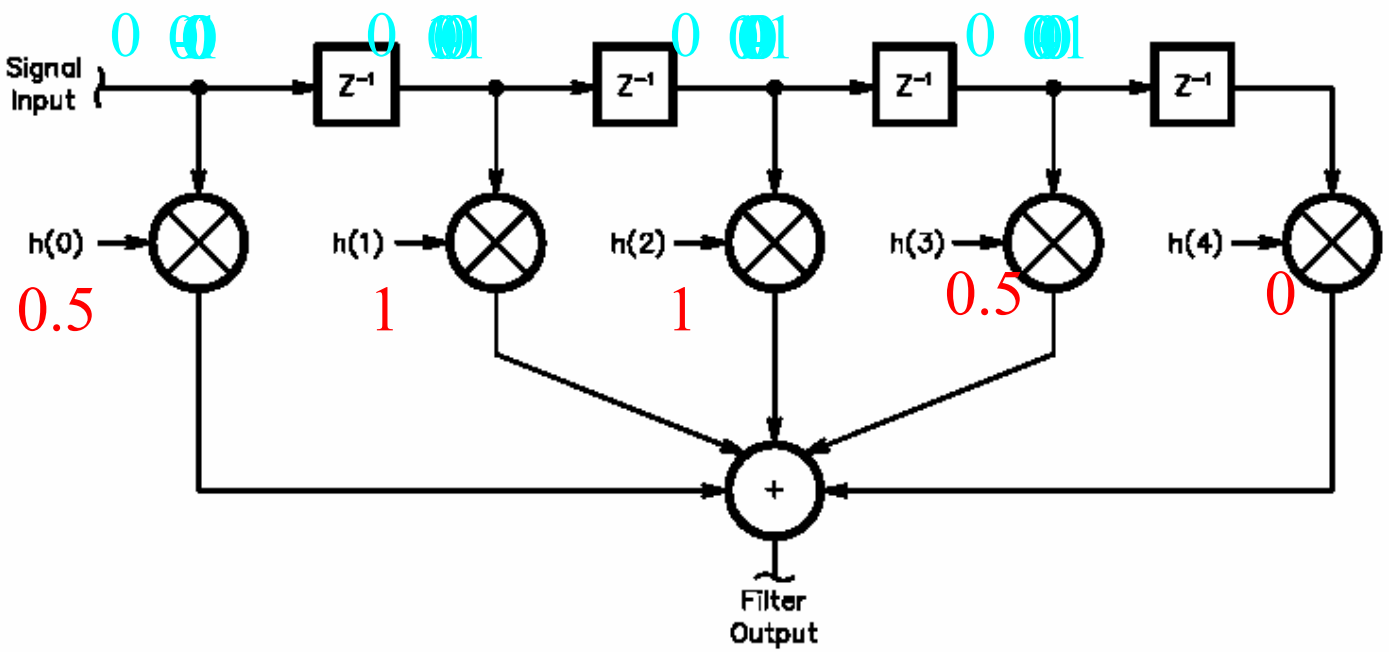


R. Barbeau, 1962
Fixing a FM radio

What is Digital Signal Processing?

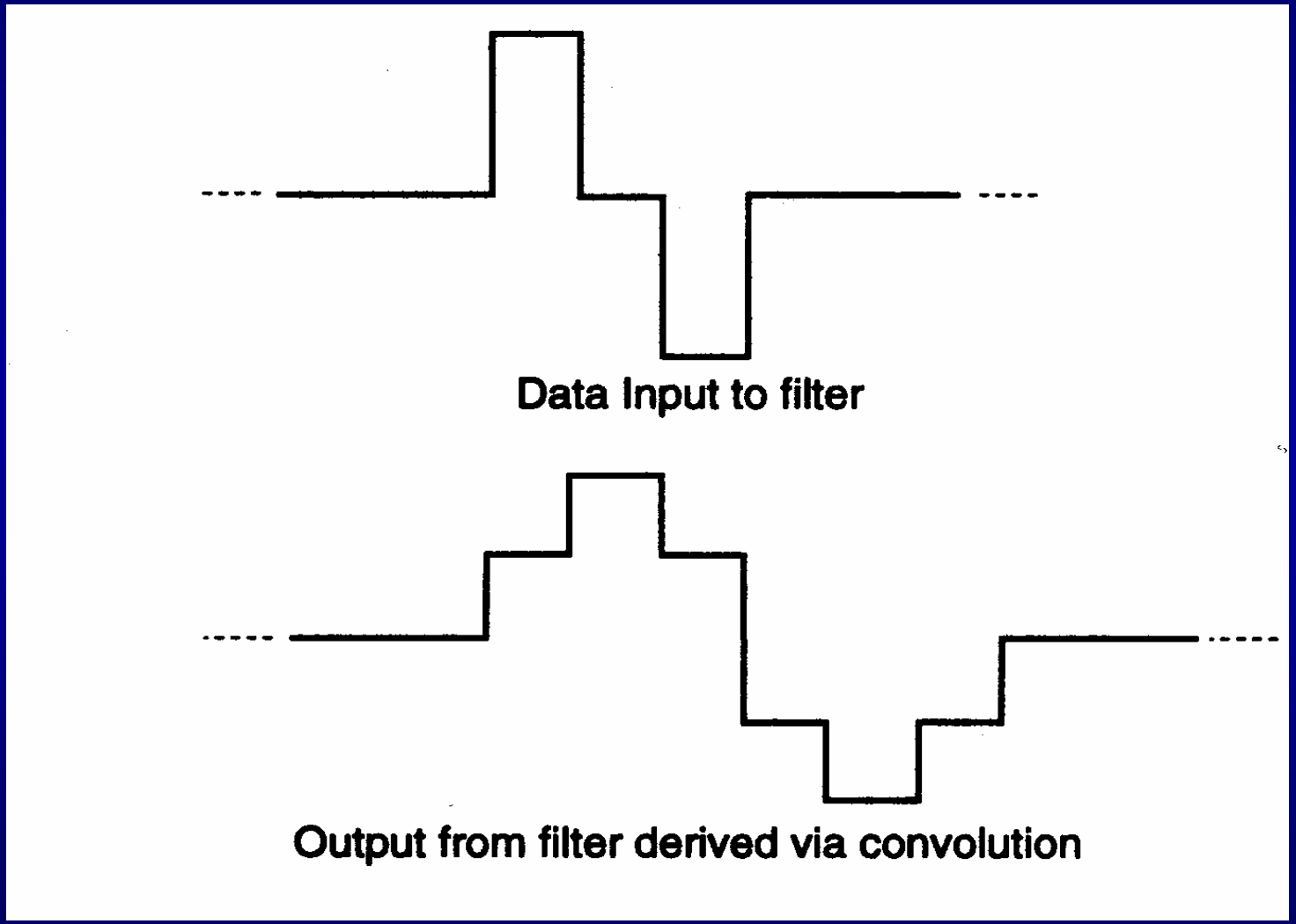
- Measuring analog signals
- Recording measurements as series of numbers
- Processing the numbers
- Converting back to analog signals

Example: Low Pass Filter



$$y(k) = \sum_{n=0}^{L-1} h(n)x(k-n)$$

Input-Output from the Filter

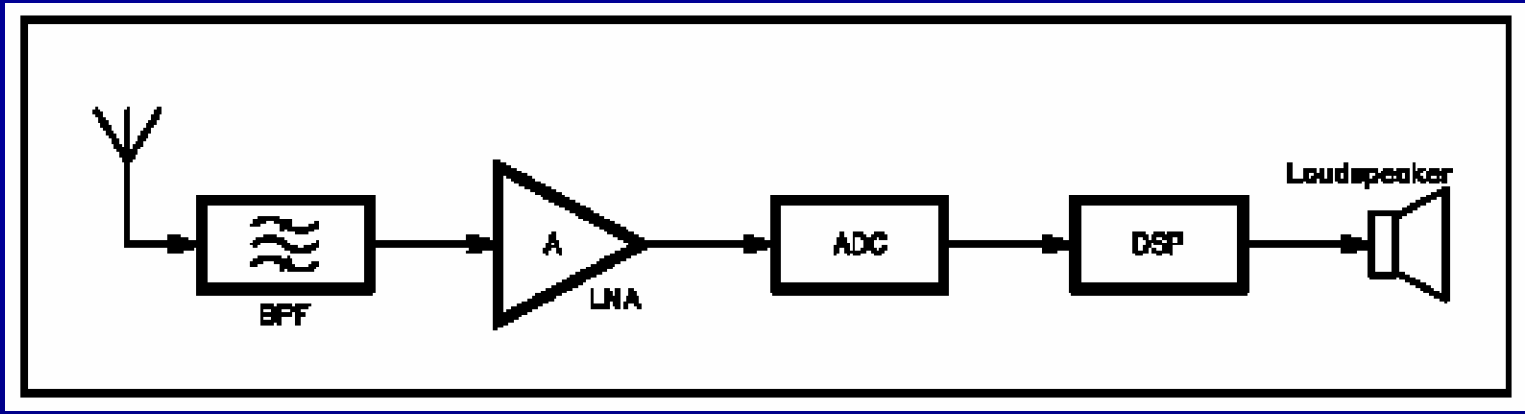


What is a Software Radio?

- Radio with functions implemented in software
- Multi-band antennas
- Transmitter
  - conversion of digital to analog (DAC), possibly to an IF and then to RF
- Receiver
  - wideband analog to digital conversion (ADC), down conversion, demodulation
- Increasing flexibility via increased programmability
- Require a multi-disciplinary approach

Software Radio Architecture

Direct Digital Conversion



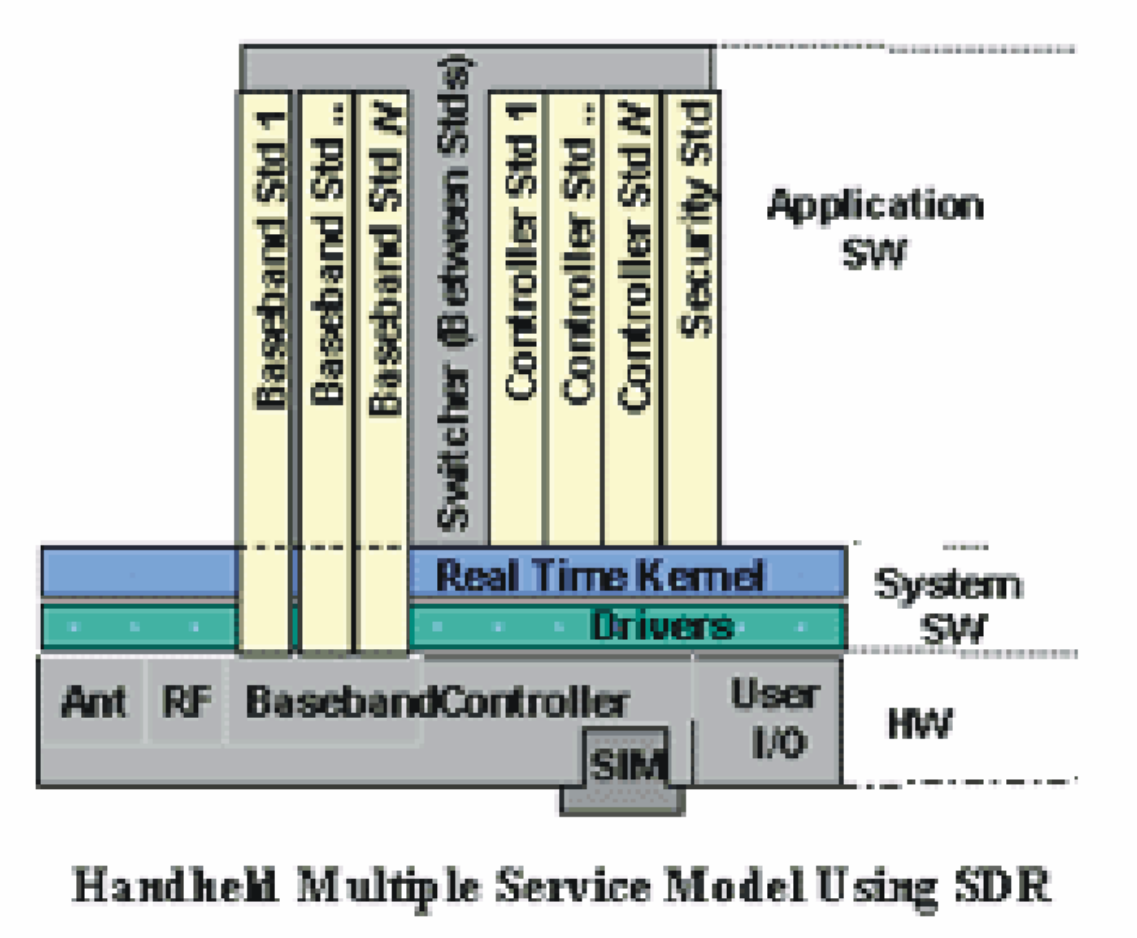
What is a Software Defined Radios?

- Radios that provides software control
- User devices and network equipment can be dynamically programmed
- Functional blocks connected via open interface standards
- Standard architecture

Application Domains

- Military and Commercial
  - Air traffic control
  - Cellular phone
  - Computer networks
  - Pervasive computing
  - Satellite telecommunications

Software Defined Radio Architecture



Handheld Multiple Service Model Using SDR

Current Standardization Efforts

- SDR Forum

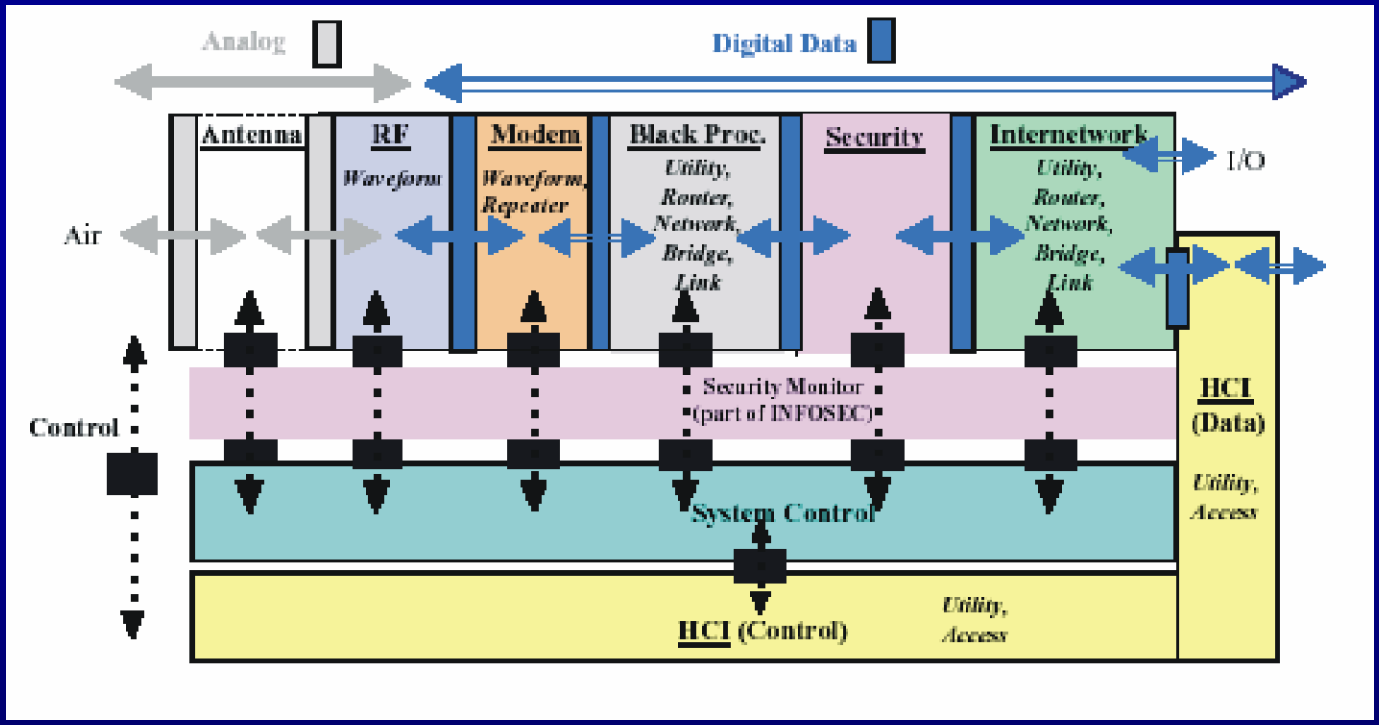
  More than 138 members including Boeing, CRC, France Telecom, Harris, Mercury Computer Systems, Motorola, Nortel Networks, Raytheon Systems, Spectrum, Thales, etc.

- Standard architecture (SCA)

  Published by Joint Tactical Radio System (JTRS) Joint Program Office (JPO)

- OMG
  - Metamodel
  - PIM
  - Platform Specific Implementations

Software Reference Model (SCA)



Proposed UML-RT Modeling Process

- Based on UML-RT
- Scenario driven
- Uses multiple views (diagrams)
- Strong requirements and inter-diagram traceability
- Automatic Code Generation from UML models

Objectives

Improve the understandability of the Software Radio Architecture (SCA) by:

- Developing a UML reference model containing different views of the architecture
- Building a simulation (executable model) enabling the user to interact and run different scenarios of SCA
- Speed up the training of new users and incorporation of new companies to accelerate the Software Radio Standardization
- Speed up SDR product development

Founded by CITO

Unified Modeling Language

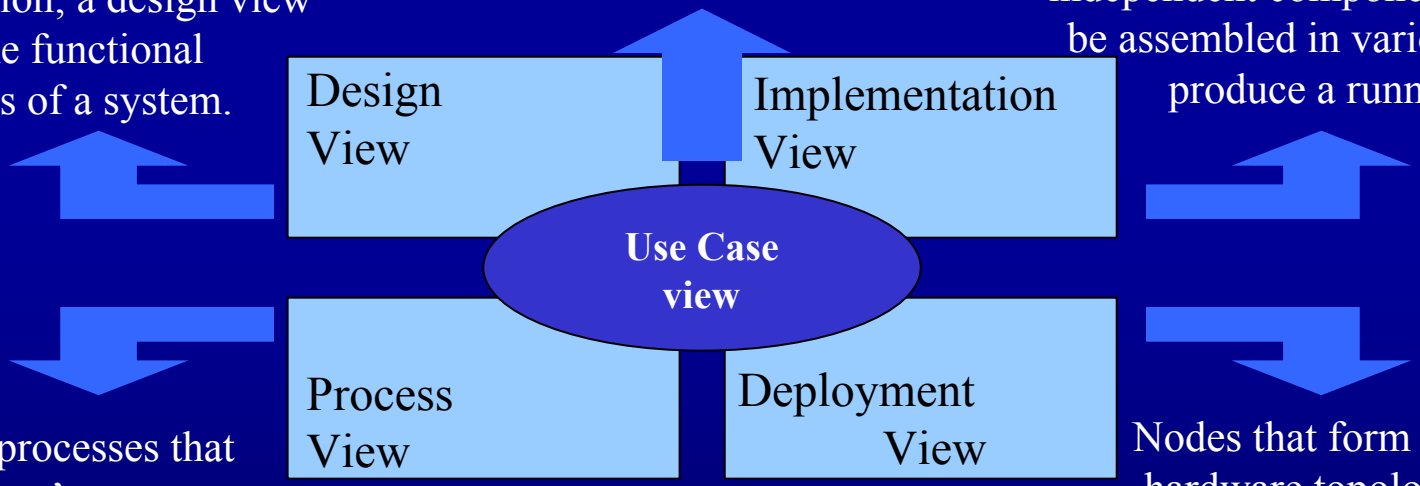
- Graphical Language for { Visualizing / Specifying / Constructing / Documenting } the artifacts of Software-based systems
- Standard for object oriented software modeling
- Allows modeling different aspects (different views)
- Allows modeling systems at different levels of abstraction
- Scenario driven process

Different Views

Classes, interfaces, and collaboration that form the vocabulary of the problem and its solution; a design view addresses the functional requirements of a system.

Uses cases that describe the behavior of the system as seen by its end users, analysts and testers.

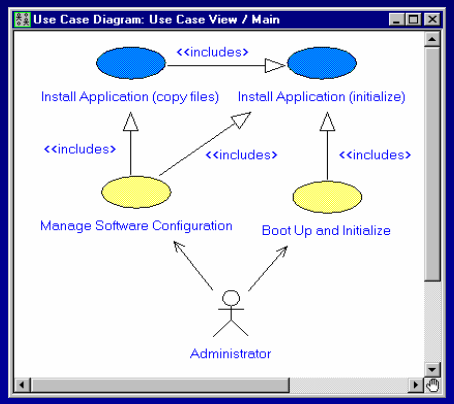
Components used to assemble and release the physical system; an implementation view addresses the configuration management of the system's releases, made up of somewhat independent components that can be assembled in various ways to produce a running system.



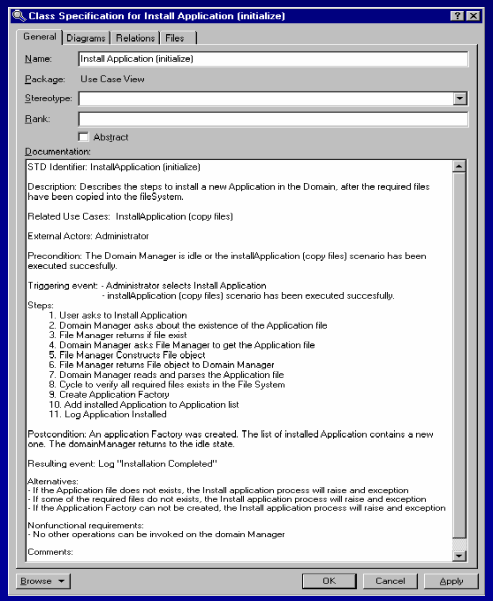
Threads and processes that form the system's concurrency and synchronization mechanisms; a process view addresses the performance, scalability, and throughput of the system.

Nodes that form the system's hardware topology on which the system executes; a deployment view addresses the distribution, delivery, and installation of the parts that make up the physical system.

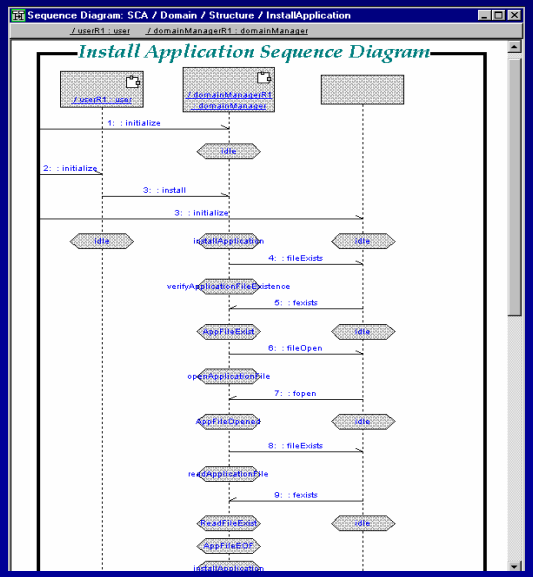
Different Diagrams



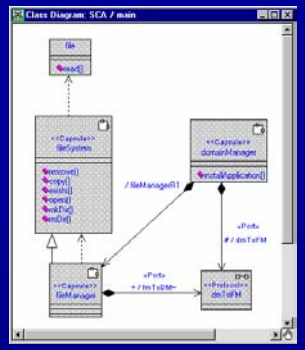
Use Case



Use Case Description

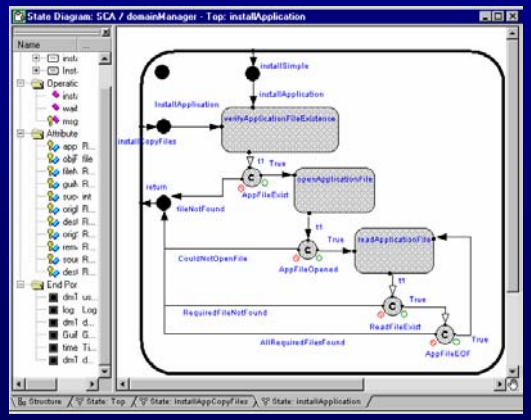


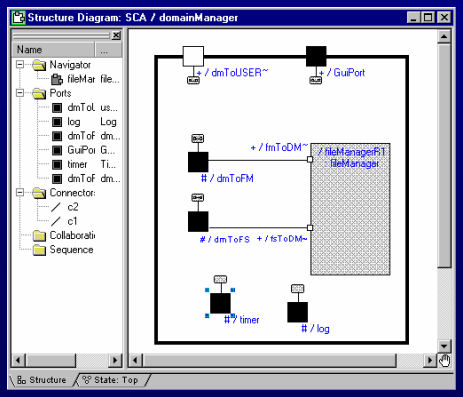
Sequence



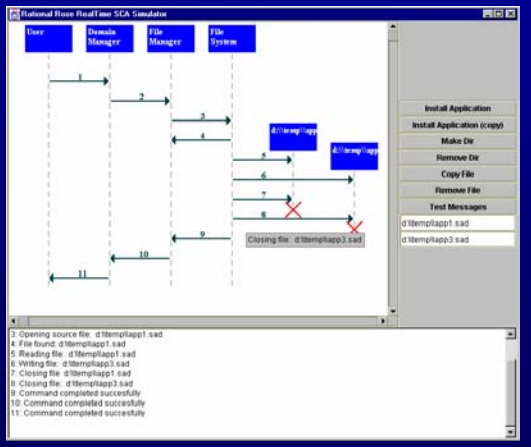
Class

Statecharts





Capsule structure

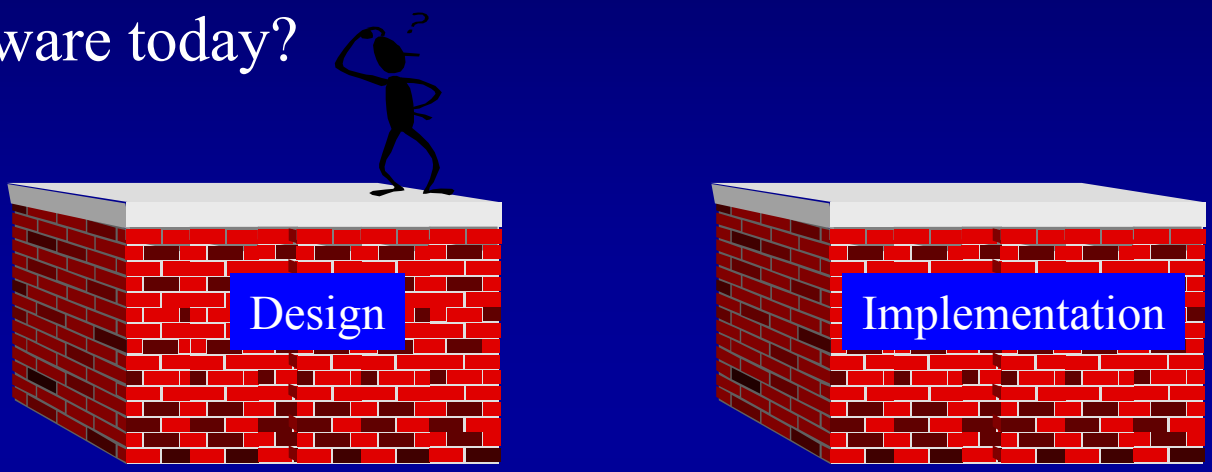


Java GUI

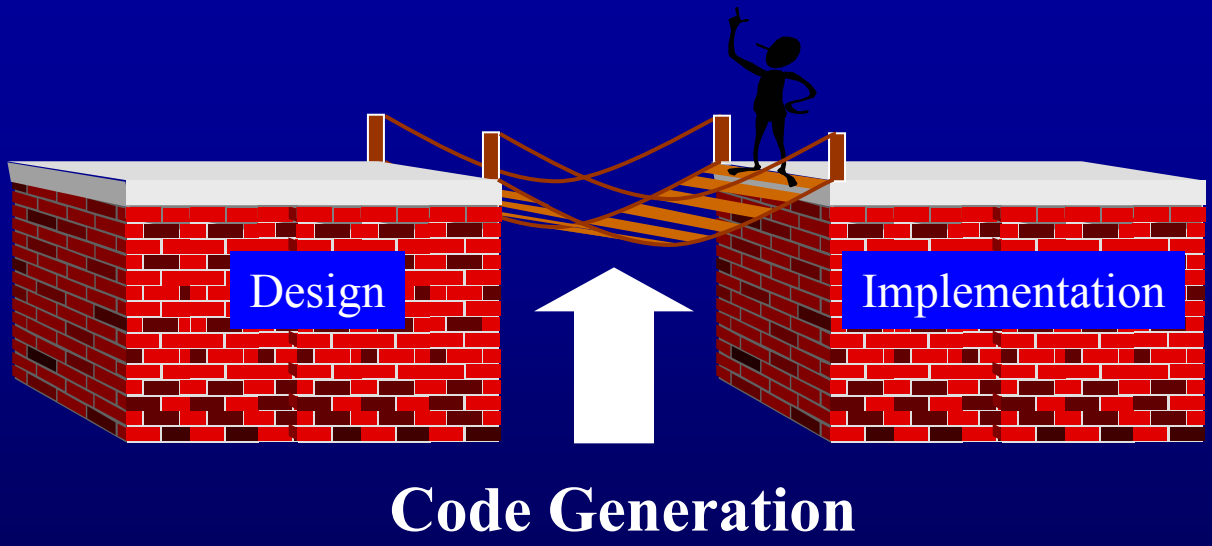
From Design to Implementation

How do we build software today?

Traditional



UML-RT



Current Projects/Collaborations

- Simulator for the SCA specification (CITO, CRC, Mercury Computer Systems)
- SDR Metamodel (Mercury Computer Systems, Mitre, Raytheon)
- Platform Independent Model (PIM) (Mercury Computer Systems and CRC)
- SCA Validation Framework (Mercury Computer Systems)