Software Communications Architecture (SCA) and Rapid Application Development

Presented by:

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Outline

- SCA Overview
- SCA and Component-Based Design (CBD)
- Rapid Application Development (RAD)
- SCA Architect ™ RAD Features
- Summary

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- **SCA Overview**
- **SCA and Component-Based Design (CBD)**
- **Rapid Application Development (RAD)**
- **SCA Architect ™ RAD Features**
- **Summary**

SCA Overview

The SCA was created for the US DoD Joint Tactical Radio System (JTRS) program

- Created by the Modular Software–programmable Radio Consortium (MSRC): Raytheon, BAE Systems, Rockwell Collins, and ITT
- Assisted by the Communications Research Centre of Canada

The goal of the SCA is to facilitate the reuse of waveform applications across different radio sets

- Technology insertion and capability upgrades

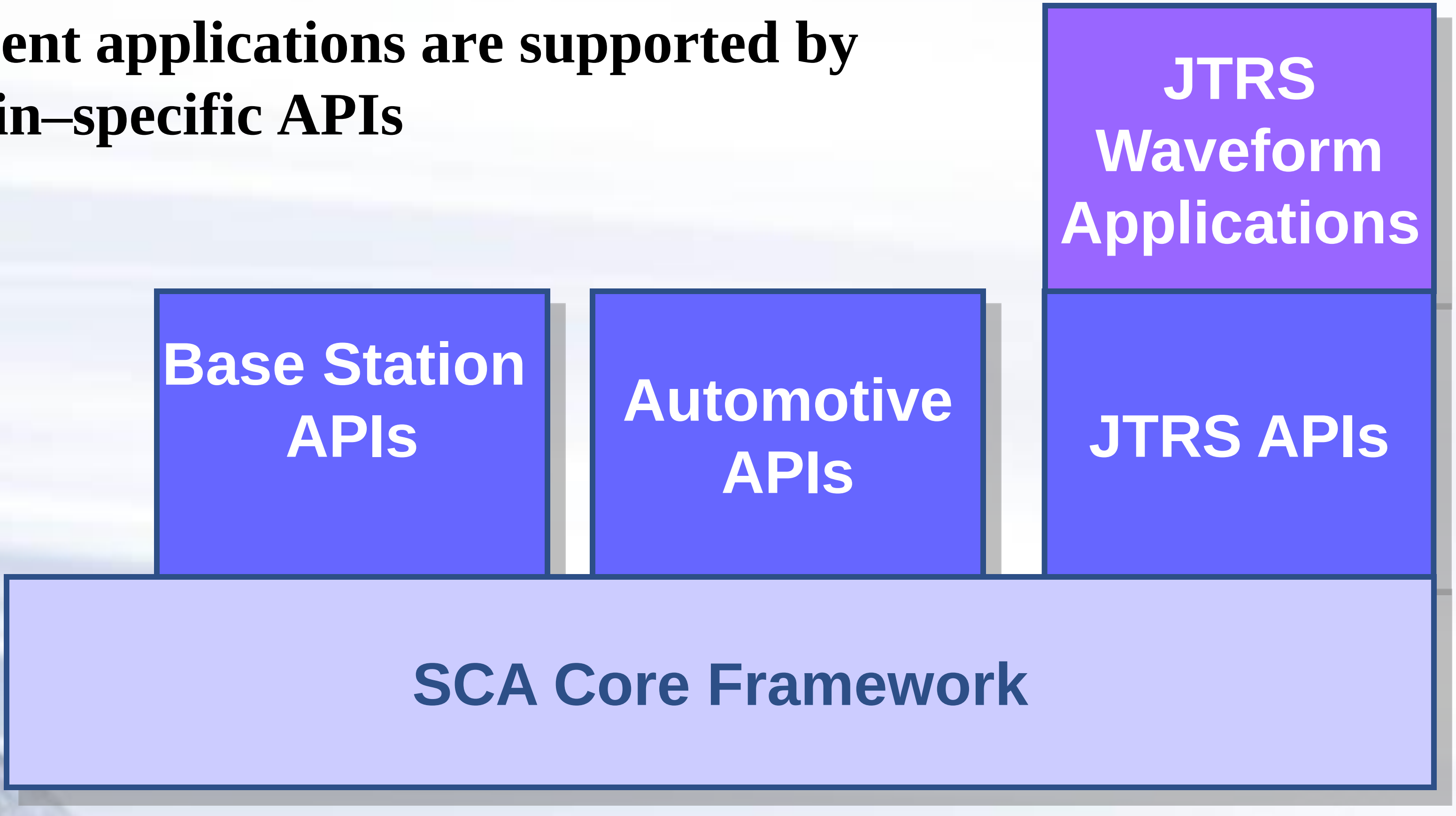
The SCA defines a central piece of software that acts as the "SDR operating system"

- SCA Core Framework

SCA Overview

The SCA is independent of the application domain

Different applications are supported by domain–specific APIs



JTRS Waveform Applications

Base Station APIs

Automotive APIs

JTRS APIs

SCA Core Framework

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SCA – Component-Based Design – A Different Perspective

The SCA is a Component-Based Design (CBD) architecture

What is Component-Based Development ?

- **Definition**: an architecture which allows the creation, integration, and re–use of software components
- CBD is a development paradigm where the smallest unit of software is a **component**
- Using CBD, an application is 'assembled' using **software components** much like a board is populated with hardware components

Characteristics of a Software Component:

- A small, reusable module of **binary code** that performs a well–defined function (i.e. a black–box)
- Designed, implemented, and tested as a unit before it is used in an application

SCA – Component-Based Design

CBD promotes the COTS culture and is enabling the industrialization of software

The goal is to use the hardware development paradigm for software:

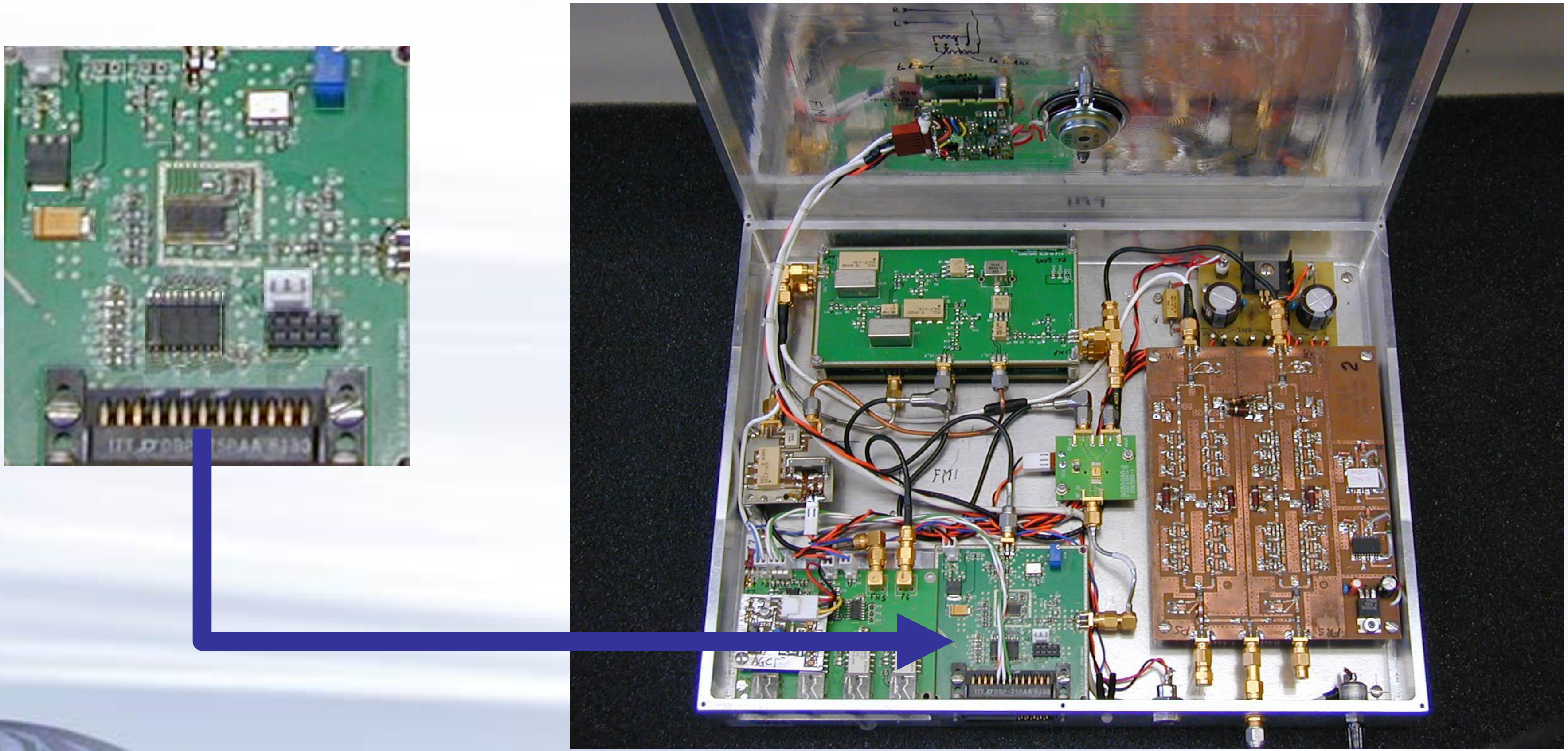
- Purchase software components from a catalog
  - Describe how to influence behavior (config properties)
  - Describe how to interface (ports)
  - Describe resource consumption (capacity properties)
  - Describe resource requirements (capability properties)

CBD is currently the most popular programming paradigm:

- Microsoft’s CBD is the “**.NET**” framework
- Sun Microsystem’s CBD is the “**EJB**” framework
- OMG’s CBD is the “**CCM**” framework

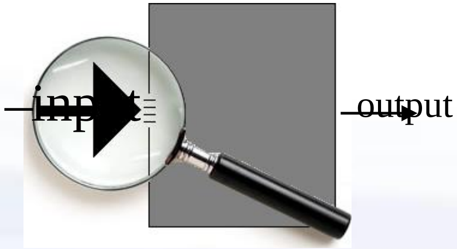
SCA – Component-Based Design

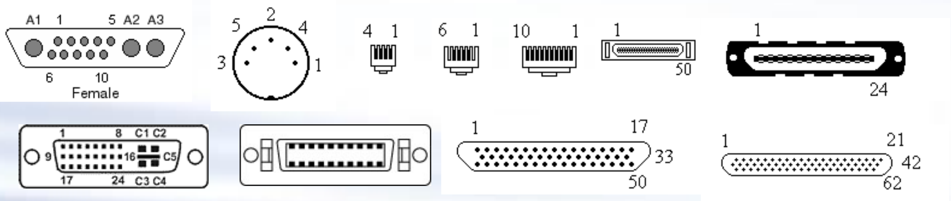
How do we build hardware ?



SCA – Component-Based Design

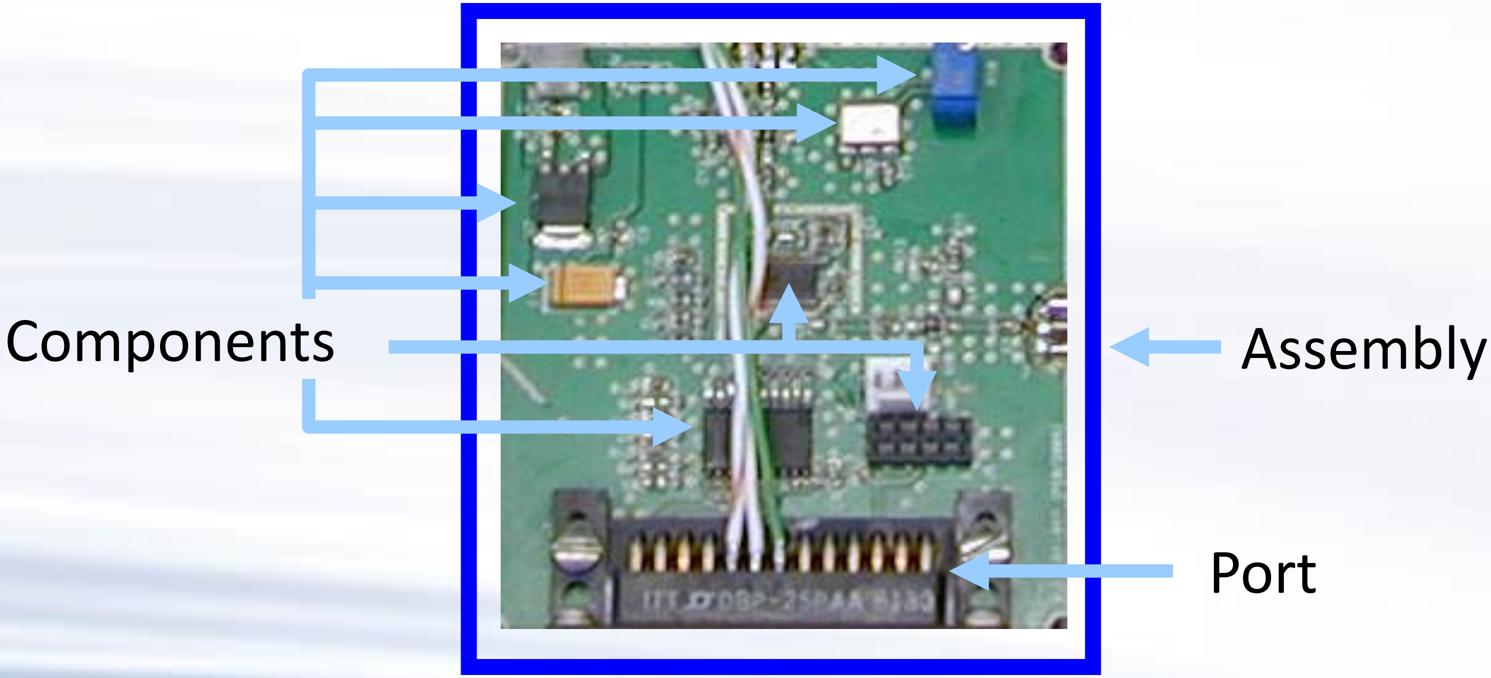
To connect hardware components, appropriate connectors must be used:





SCA – Component-Based Design

Definitions; Back to the small board...



Components

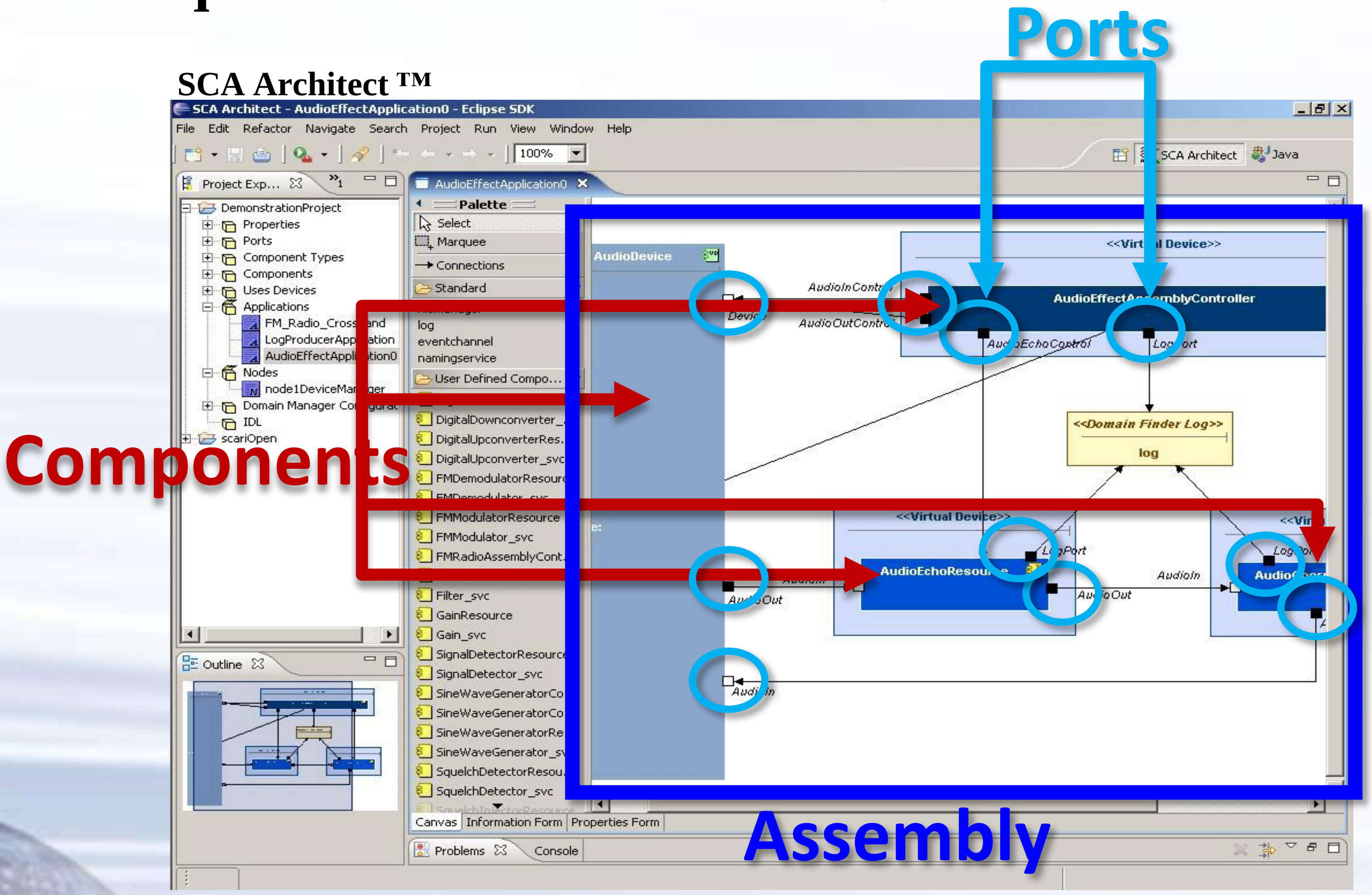
Assembly

Port

SCA – Component-Based Design

Software equivalent of the small board:

SCA Architect ™



SCA – Component-Based Design

With the SCA, there are two types of constructs:

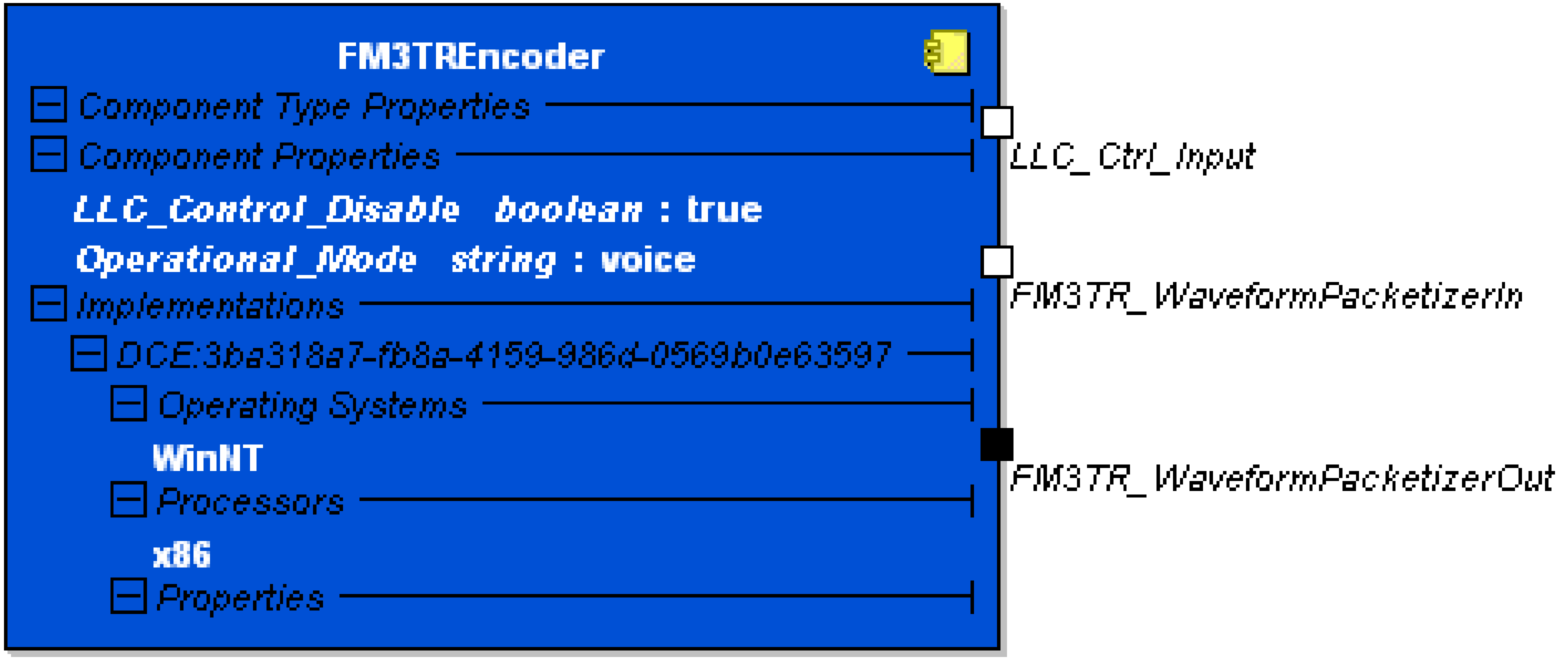
1. **Components:**
   - Some SCA components are provided with SCA Core Framework product
     - Ex: DomainManager, DeviceManager, Log service, File, FileSystem, FileManager, Event channels, etc.
   - Other components are created by platform providers and application developers
     - Ex: Resource, ResourceFactory, Device, LoadableDevice, ExecutableDevice, etc.

2. **Assemblies:**
   - Defined as a collection of application or node components

SCA – Component-Based Design

SCA components are described by 3 kinds of modeling elements:

1. **Ports:** used to get data to/from a component
2. **Properties:** used to alter the behaviour of a component
3. **Implementations:** used to describe which operating environments a component supports



FM3TREncoder

Component Type Properties

Component Properties

LLC_Control_Disable boolean : true

Operational_Mode string : voice

Implementations

DCE:3ba318a7-fb8a-4159-986d-0569b0e63597

Operating Systems

WinNT

Processors

x86

Properties

LLC_Ctrl_Input

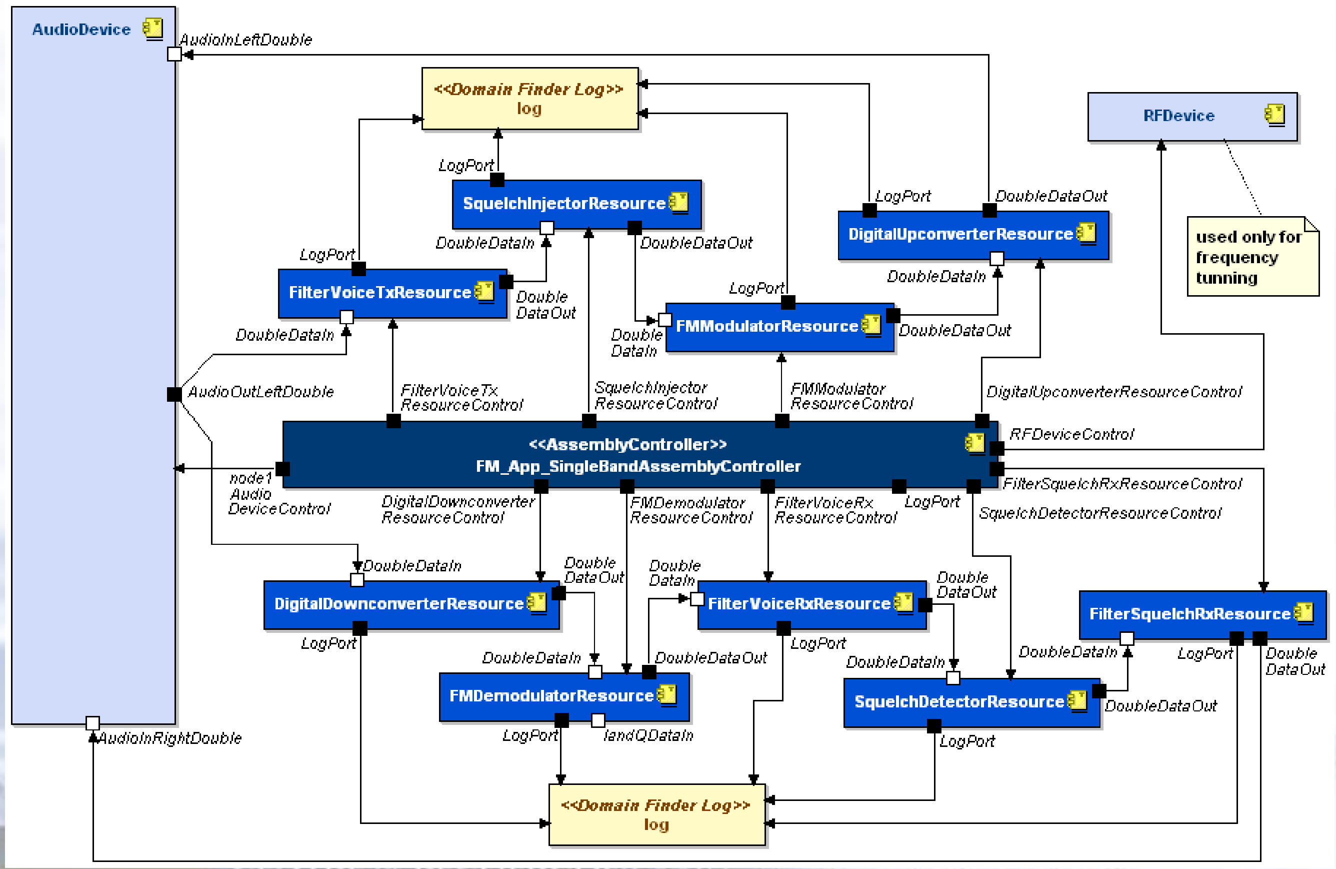
FM3TR_WaveformPacketizerIn

FM3TR_WaveformPacketizerOut

SCA – Component-Based Design

SCA applications are described by 2 kinds of modeling elements:

1. **Component Instantiations:** which components are part of the application
2. **Connections:** how instantiations are interconnected



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Rapid Application Development

What is Rapid Application Development (RAD) ?

- Development process invented by James Martin in the 1980s
- Involves iterative development and use some form of Model Driven Development (MDD) tool

Rapid means ***Fast***!

- The RAD process is optimized for speed and relies on two key concepts: Prototyping and Iteration
- Prototyping: creating a demonstrable result as early as possible
- Iteration: commitment to incremental development based on refinement
- Prototyping and Iteration go hand–in–hand

Rapid Application Development

Advantages of Rapid Application Development:

- **Clarity/precision:** Development starts at a higher level of abstraction
- **Portability:** High–level abstractions are translated into platform specific artifacts
- **Early visibility:** Can quickly create prototypes
- **Greater flexibility:** Developers can redesign almost at will
- **Fewer defects:** Because of modeling wizards and model translation which greatly reduce manual coding
- **Reduced cost:** Shorter development cycles, time is money!

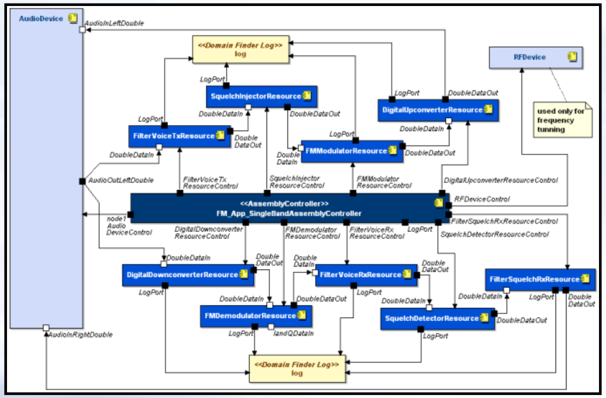
Rapid Application Development

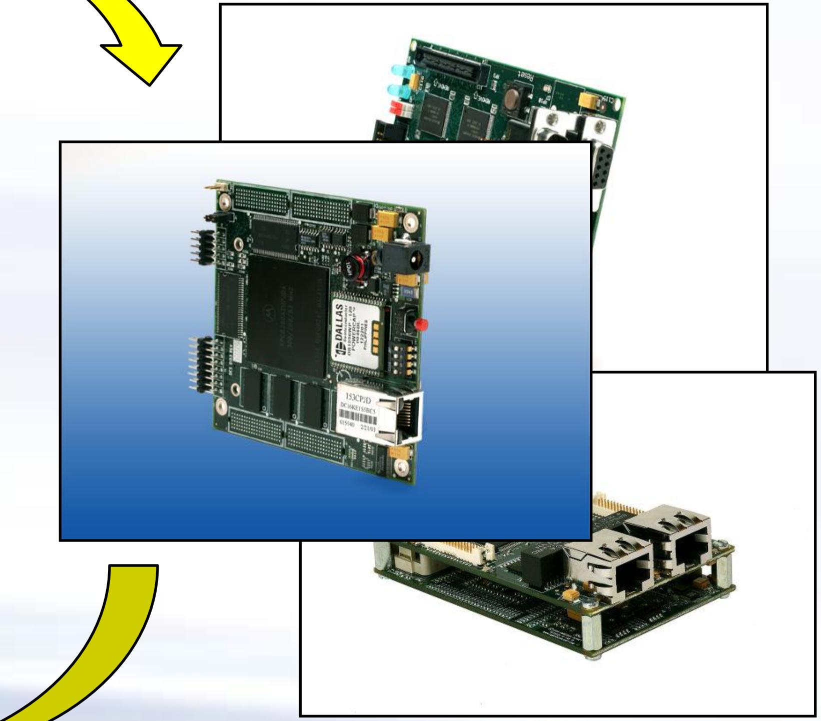
RAD requires specialized tools that provide:

- **Graphical development/modeling:** to support a high level of abstraction
- **Creation of working prototypes:** for early visibility and greater flexibility
- **Multiple operating environments:** to support portability and greater flexibility
- **Teamwork/collaboration and version control :** because of early visibility and greater flexibility
- **Reusable artifacts:** to support shorter development cycles and reduced cost

Rapid Application Development

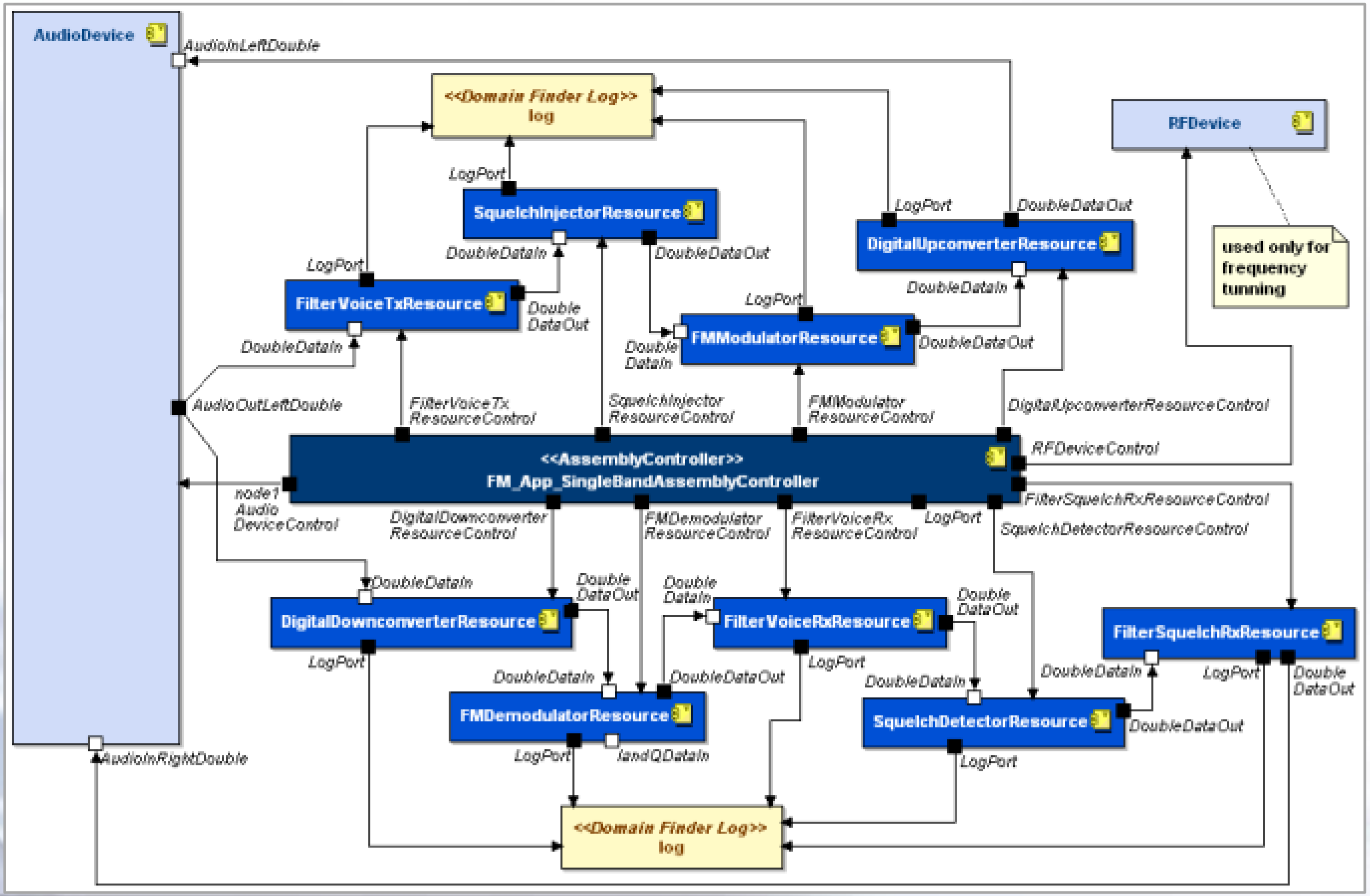
Concept of graphical development also known as Model–Driven Development (MDD):





Rapid Application Development

The development of a SCA assemblies is achieved by assembling a number of components together:



Rapid Application Development

Development of a SCA applications can be performed using an iterative process

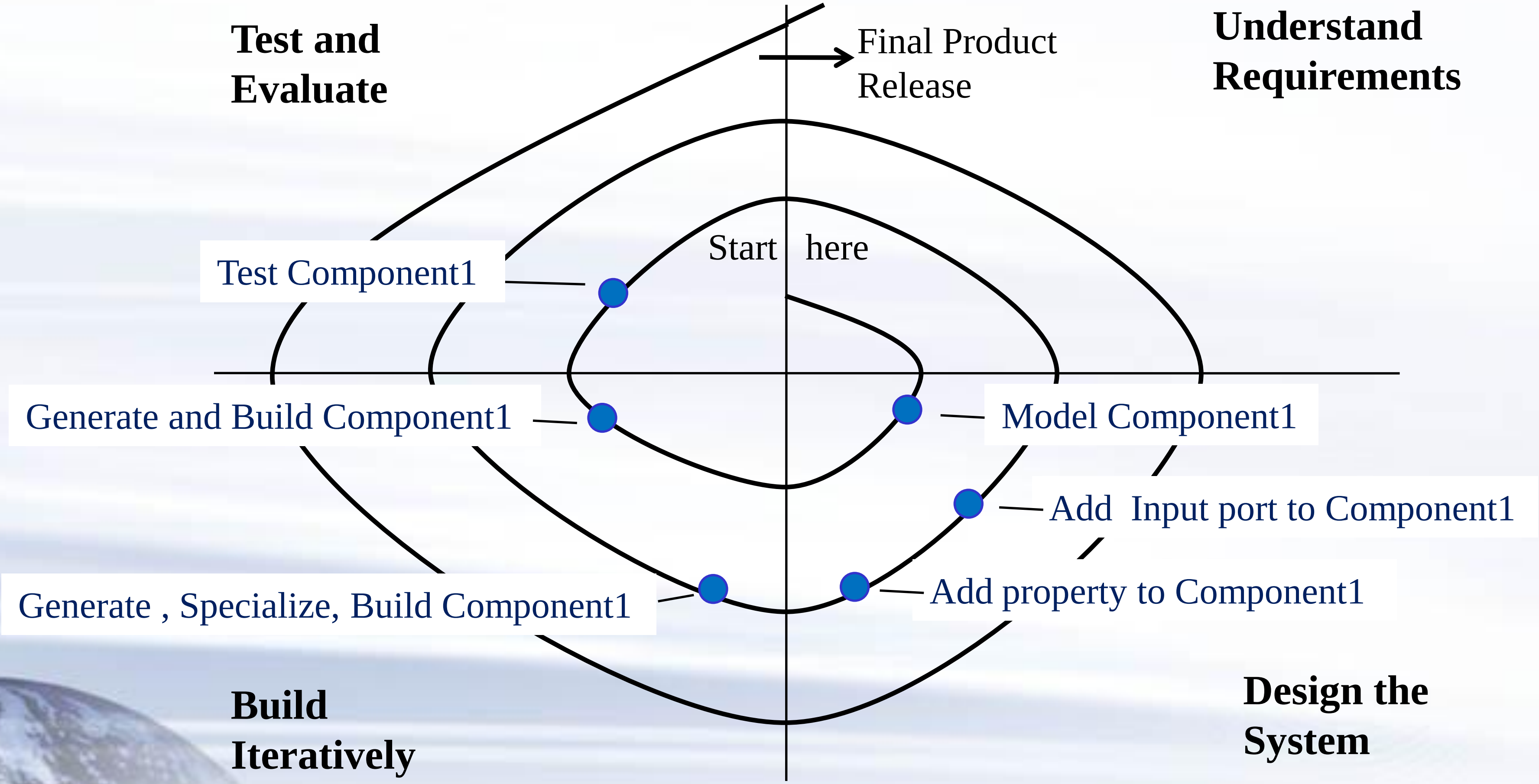
Iterative refinement happens at two levels :

1. **Component level example:**
   - Create a component with two ports and a couple of properties
   - Successively refine by adding business logic, ports and/or properties

2. **Assembly level example:**
   - Create an application made of a few components
   - Successively refine by adding more components, connections
   - Can also refine by requesting that some components be collocated or by overriding default values for component properties

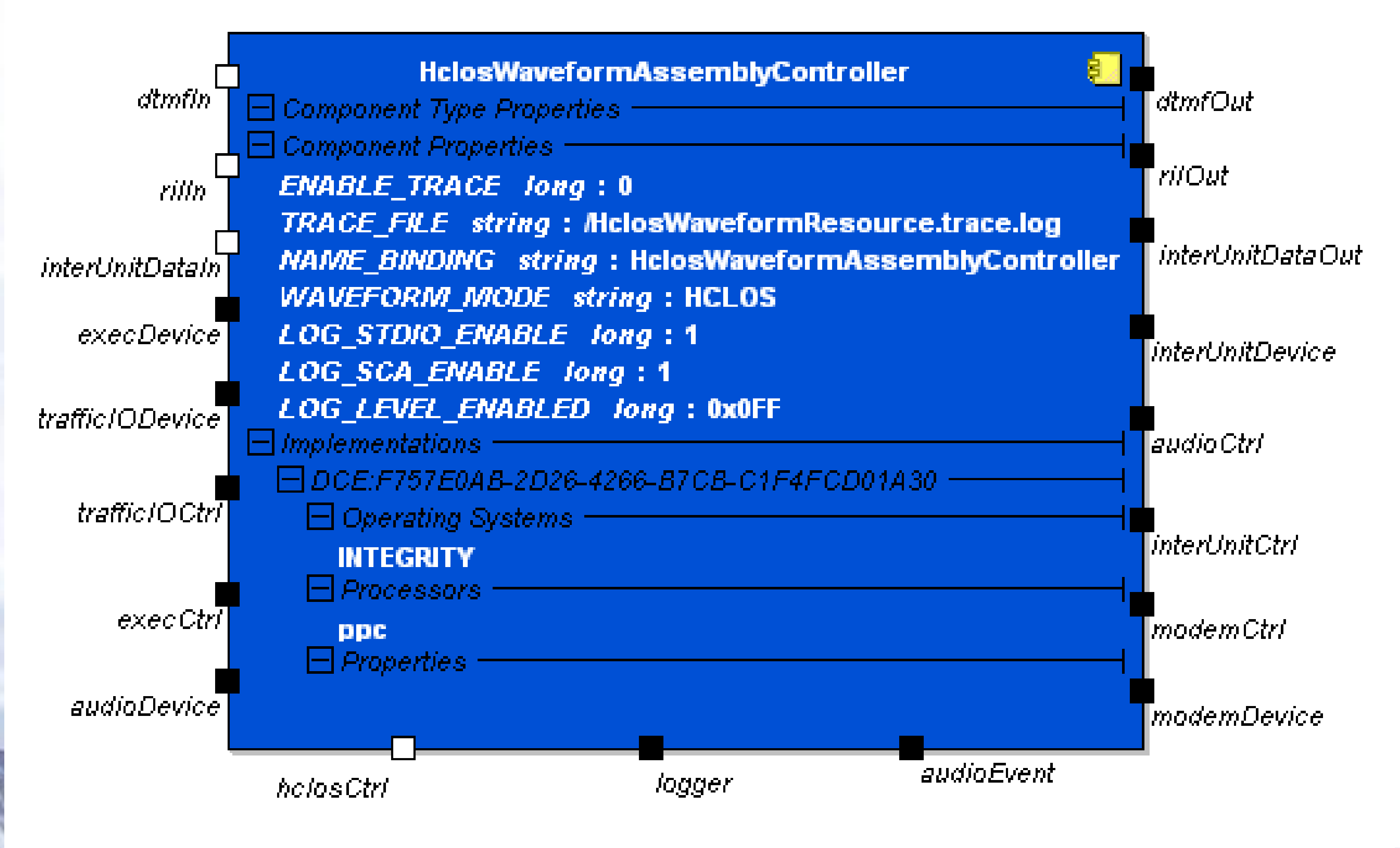
Rapid Application Development

Typical iterations for development of a component :



Rapid Application Development

Graphical view of the refinement process for a component:



HclosWaveformAssemblyController

⊟ Component Type Properties

⊟ Component Properties

ENABLE_TRACE long : 0

TRACE_FILE string : /HclosWaveformResource.trace.log

NAME_BINDING string : HclosWaveformAssemblyController

WAVEFORM_MODE string : HCLOS

LOG_STDIO_ENABLE long : 1

LOG_SCA_ENABLE long : 1

LOG_LEVEL_ENABLED long : 0x0FF

⊟ Implementations

⊟ DCE:F757E0AB-2D26-4266-B7CB-C1F4FCD01A30

⊟ Operating Systems

INTEGRITY

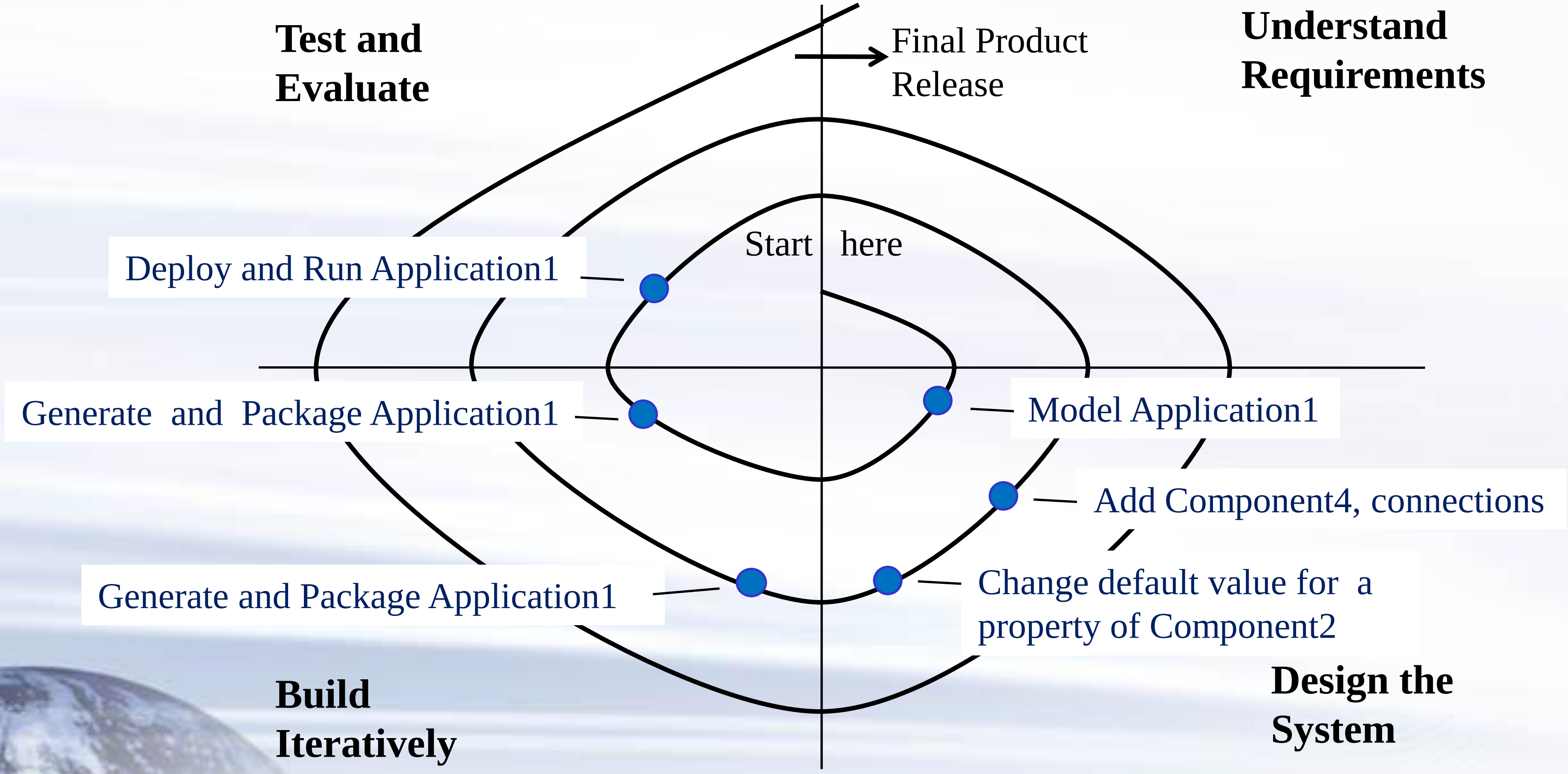
⊟ Processors

ppc

⊟ Properties

Rapid Application Development

Typical iterations for development of an assembly:



Test and Evaluate

Final Product Release

Understand Requirements

Start here

Deploy and Run Application1

Generate and Package Application1

Model Application1

Add Component4, connections

Generate and Package Application1

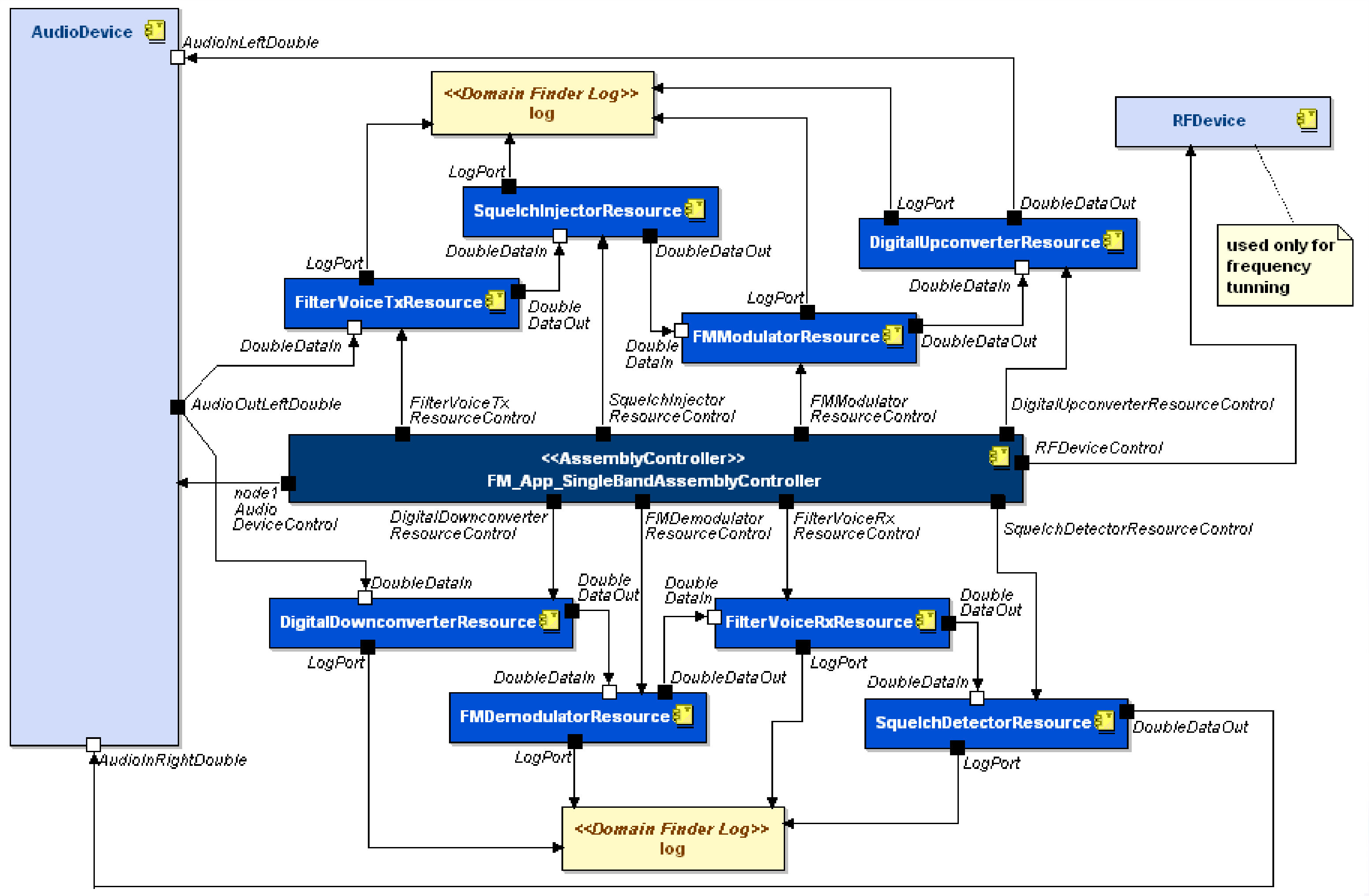
Change default value for a property of Component2

Build Iteratively

Design the System

Rapid Application Development

Graphical view of the refinement process for an assembly:



Rapid Application Development

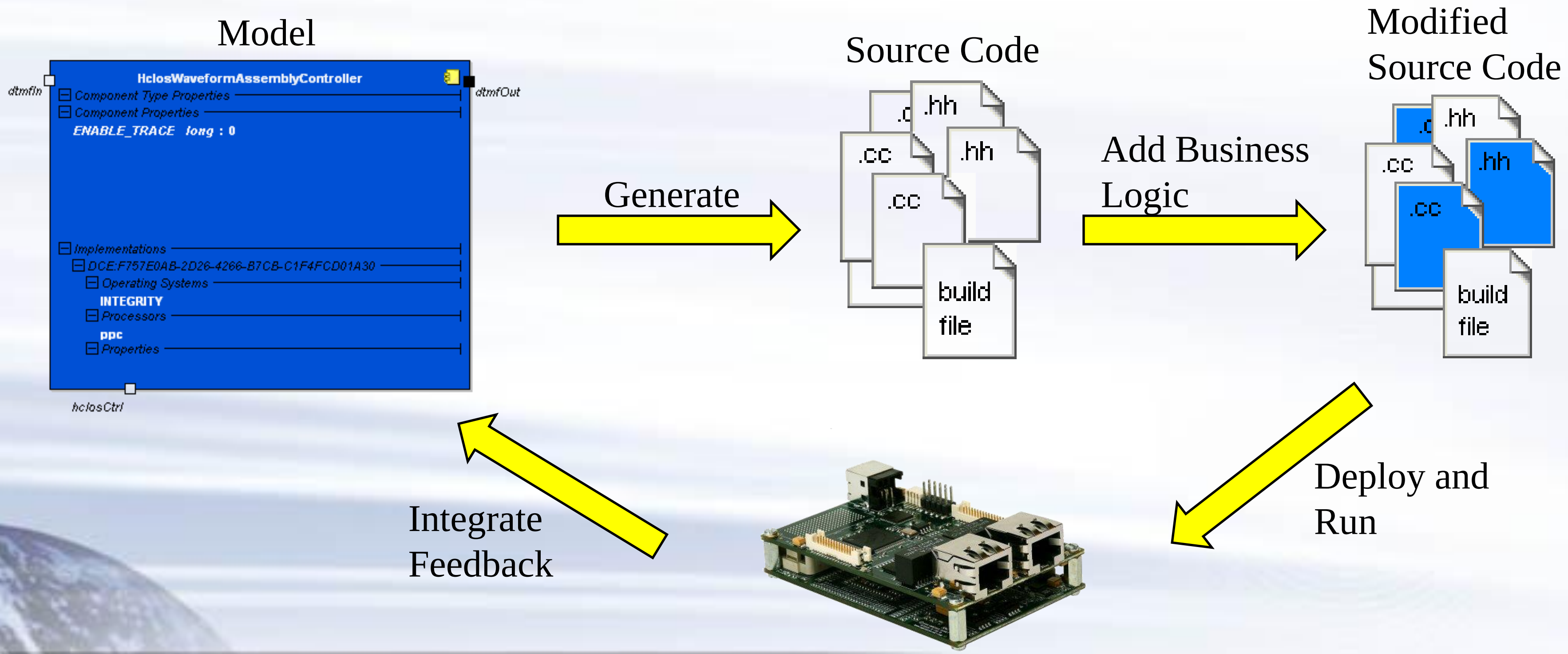
The refinement process actually happens at both the component and assembly level simultaneously:

- Create Component1 with two ports and a couple of properties
- Create Application1 which includes Component1
- Deploy and run Application1
- Refine Component1 by adding business logic, ports, properties
- Refine the Application1 by adding more components, connections
- Deploy and run new revision of Application1
- Refine Application1a by collocating some components
- Refine Application1a by overriding default values for component properties
- Deploy and run Application1b
- Etc.

Rapid Application Development

RAD tools must support short cycles to promote refinement:

- Must be very simple to successively refine a model
- Must be easy to translate models into source code
- Translation must be flexible and generate as much functionality as possible



Model

Generate

Source Code

Add Business Logic

Modified Source Code

Deploy and Run

Integrate Feedback

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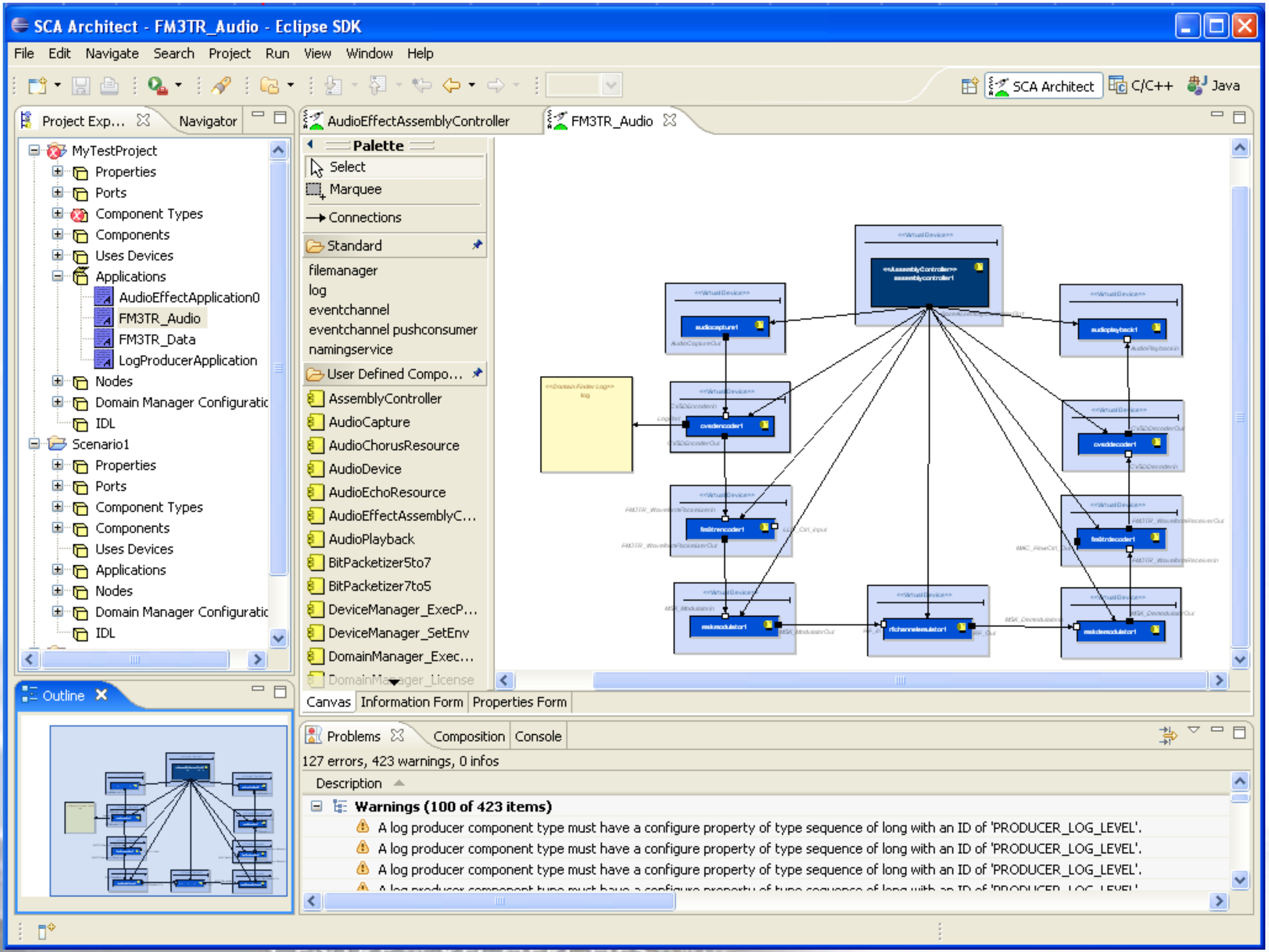
SCA Architect™ Overview

CRC’s SCA modeling tool: SCA Architect™



127 errors, 423 warnings, 0 infos

Warnings (100 of 423 items)

- ⚠ A log producer component type must have a configure property of type sequence of long with an ID of 'PRODUCER_LOG_LEVEL'.
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SCA Architect™ Overview

SCA Architect™ main characteristics:

- Eclipse–based:
  - Platform independence, easy integration with third party tools, wealth of free plug–ins, etc.
- Supports modeling of every SCA concept graphically
  - *Application assemblies:* Resource instantiations , ResourceFactory, all types of connections, host–collocation, etc.
  - *Node assemblies*: Device instantiations, Device aggregations, use device relationships, all types of connections, etc.
- Translates models into source code, build files, documentation, etc.
- Supports multiple target Operating Environments (OEs)
- Provides real–time validation of models
- Provides reverse–engineering of SCA domain profile files
- Enables configuration management
- Etc.

SCA Architect™ RAD Features

Most importantly, SCA Architect™ is a RAD tool:

- Already supports several RAD features both at the component and at the assembly level

Component–level RAD features:

1. Flexible and Comprehensive Code Generation
2. Zero–Merge Code Generation
3. Model Refactoring
4. Quick–fixes

Assembly–level RAD features:

1. AssemblyController Modeling and Code Generation
2. ResourceFactory Modeling and Code Generation

SCA Architect™ – Component-Level RAD Features

1. **Flexible and Comprehensive Code Generation:**
   a. Generates a fully functional component out of the box

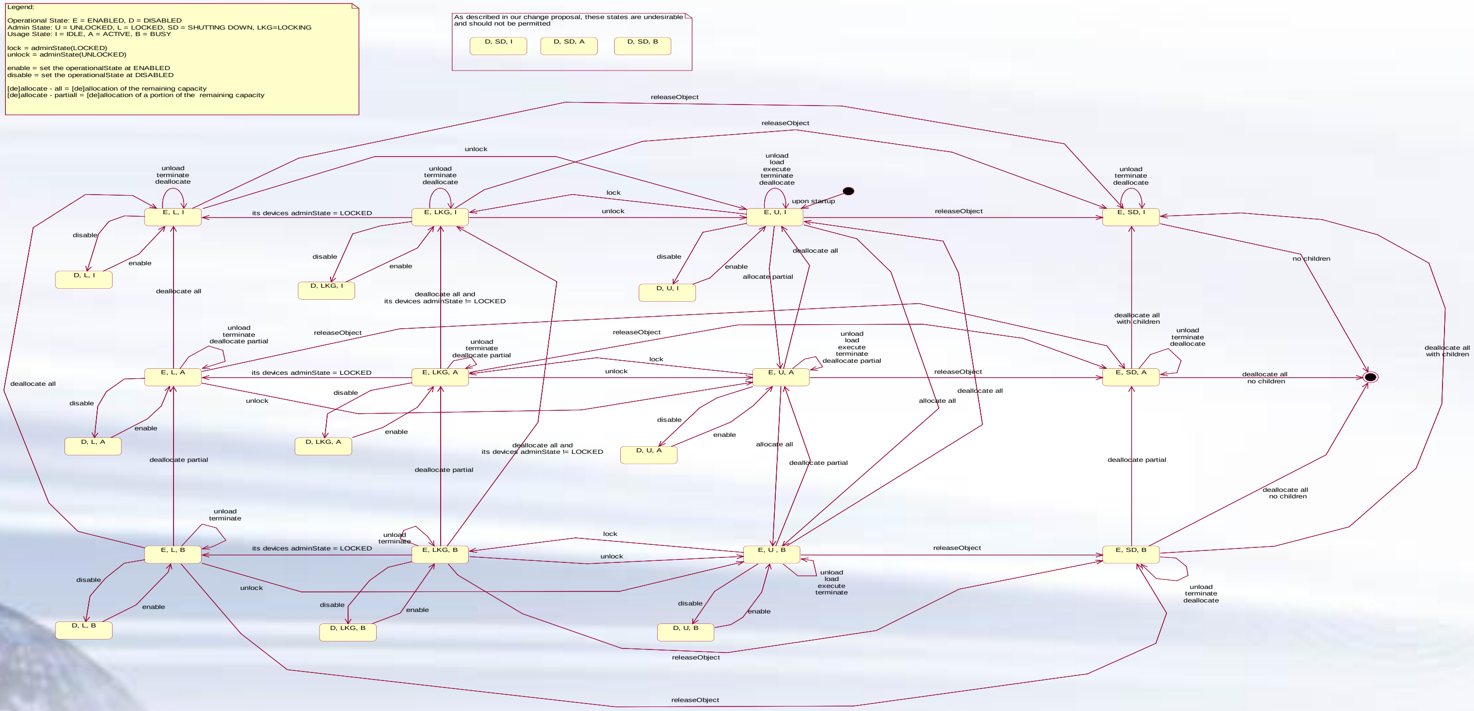
   b. Provides a Framework to handle component properties:
      - Type, Range and Enumeration validations are taken care of automatically
      - Transparently handles SCA requirements:
        - Raises proper exceptions when validation problems occur
        - Supports empty queries
      - Abstract CORBA intricacies
        - Querying a property is mapped to a C++ getter
        - Changing a property is mapped to a C++ setter
        - ‘struct’ type of property is mapped to a C++ structure
        - ‘structsequence’ type of property is mapped to a C++ array of structures

SCA Architect™ – Component-Level RAD Features

1. Flexible and Comprehensive Code Generation (cont):

c. Provides a framework to handle capacity properties:

- Allocation and deallocation of capacity is automatically handled
- Required Device state management is also automatically handled
  - – 21 states and close to 70 transitions



Legend:

Operational State: E = ENABLED, D = DISABLED
Admin State: U = UNLOCKED, L = LOCKED, SD = SHUTTING DOWN, LKG=LOCKING
Usage State: I = IDLE, A = ACTIVE, B = BUSY

lock = adminState(LOCKED)
unlock = adminState(UNLOCKED)

enable = set the operationalState at ENABLED
disable = set the operationalState at DISABLED

[de]allocate - all = [de]allocation of the remaining capacity
[de]allocate - partiall = [de]allocation of a portion of the remaining capacity

As described in our change proposal, these states are undesirable and should not be permitted

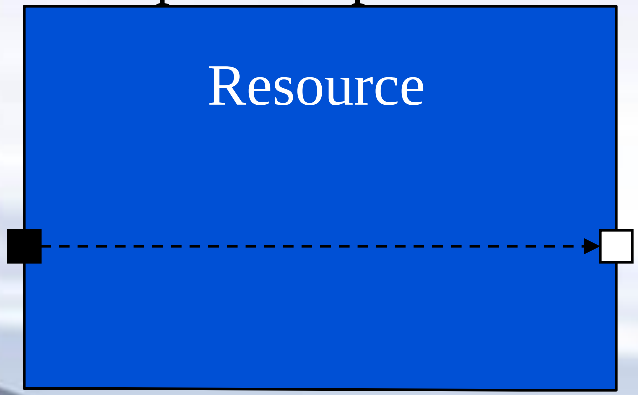
SCA Architect™ – Component-Level RAD Features

1. Flexible and Comprehensive Code Generation (cont):

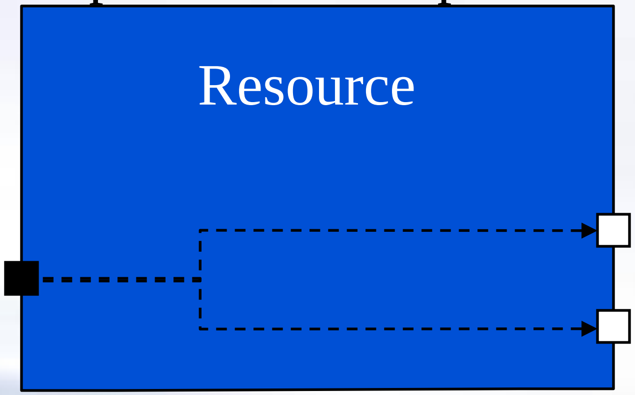
d. Provides a Framework to route packets from input ports to output ports:

- Connection handling is done automatically
- Data processing is controlled via the component start/stop
- Data processing simply requires the implementation of one method
  - Default behavior is "pass through"

point to point

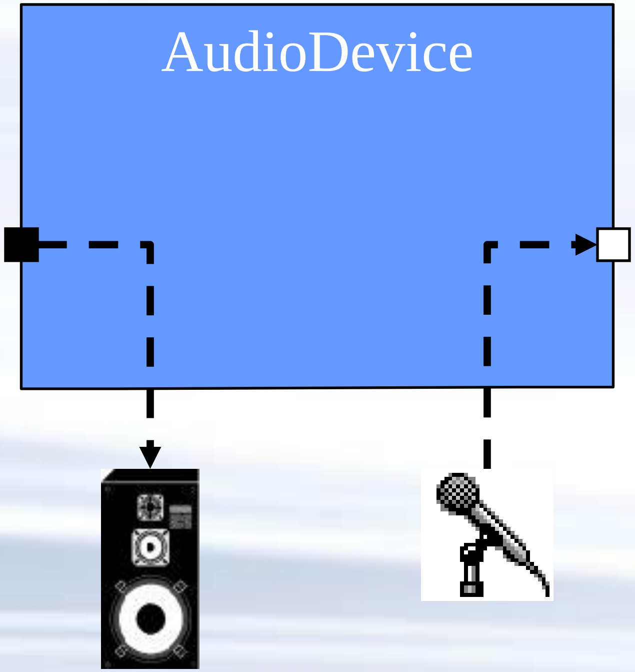


point to multi–point



SCA Architect™ – Component-Level RAD Features

1. **Flexible and Comprehensive Code Generation (cont):**
   e. Provides the option of generating a thread to pump data out:
   - Thread processing is controlled via the component start/stop
   - Data acquisition simply requires the implementation of one method

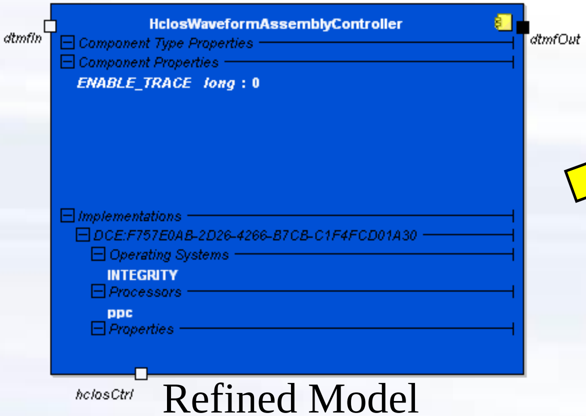


SCA Architect™ – Component-Level RAD Features

2. Zero–Merge Code Generation:

a. Supports iterative refinement without any merge tool

b. Merging source code is very error prone and cumbersome



dtmfIn

HclosWaveformAssemblyController

dtmfOut

⊟ Component Type Properties

⊟ Component Properties

ENABLE_TRACE long : 0

⊟ Implementations

⊟ DCE:F757E0AB-2D26-4266-B7CB-C1F4FCD01A30

⊟ Operating Systems

INTEGRITY

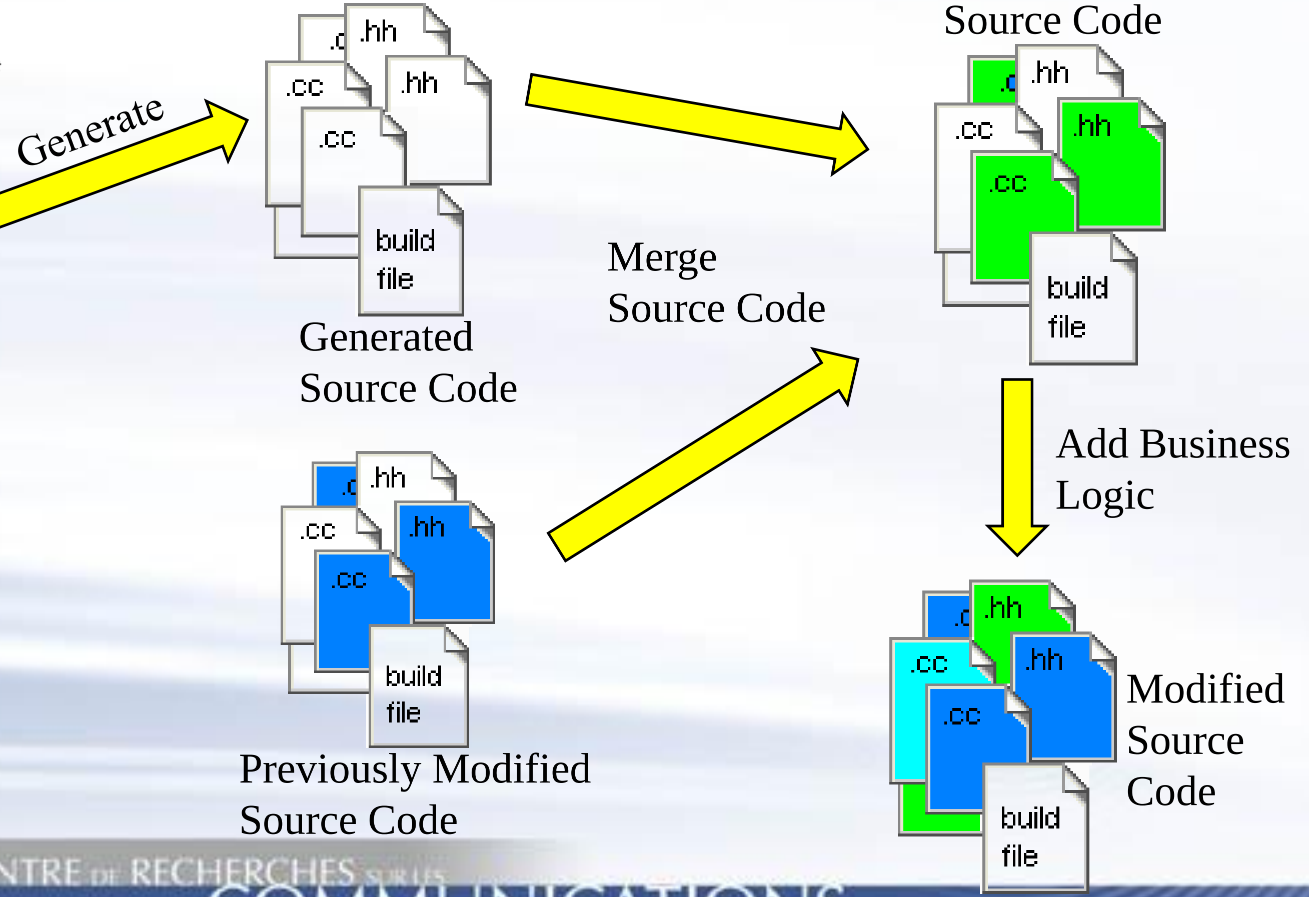
⊟ Processors

ppc

⊟ Properties

hclosCtrl

Refined Model



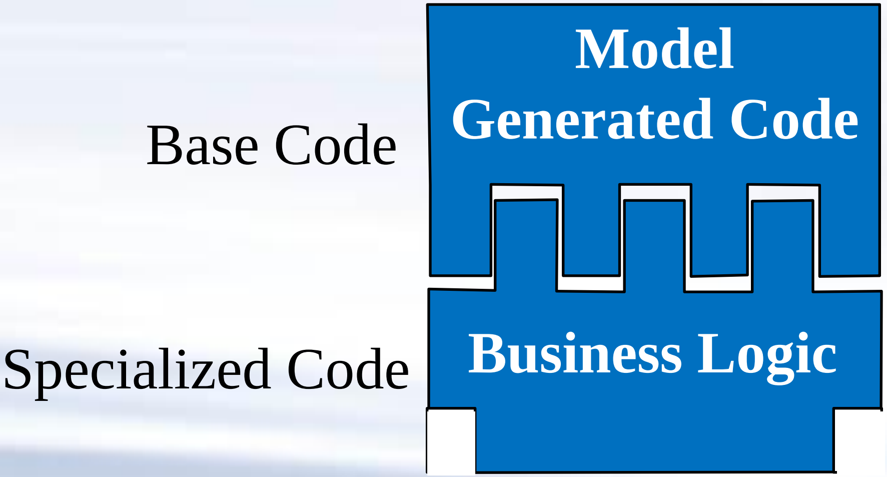
SCA Architect™ – Component-Level RAD Features

2. Zero–Merge Code Generation (cont):

c. Is achieved by keeping the business logic separate from the model generated code

d. Base Code: Generated from the model

e. Business Logic: Specializes the base code



SCA Architect™ – Component-Level RAD Features

2. Zero–Merge Code Generation (cont):

f. Model can be refined several ways without requiring a merge:

- Can add/remove a property
- Can edit a property to add/remove/change range or enumeration validations
- Can add/remove a port
- Can add/remove fields to a property of type structure
- Generated code can always be specialized

SCA Architect™ – Component-Level RAD Features

3. Model Refactoring:

a. Model can be refactored comprehensively:

- The model of a Property being used by several components can be changed across a whole project
- The same is true for Ports and Components

4. Quick Fixes:

a. After reverse–engineering SCA domain profile files, validation may produce several errors and warnings

b. Fixing errors/warning manually can be very tedious

c. SCA Architect offers an automated way of fixing problems:

- Don’t have to edit a form to repair the problem; choose from alternatives fixes
- Can apply the same fix to all similar problems

SCA Architect™ – Assembly-Level RAD Features

1. **AssemblyController (AC) Modeling and Code Generation**
   a. Using a wizard, SCA Architect™ can generate an AC model from an application assembly model:
      - Specify which component needs to be controlled
      - Specify which port / property needs to be exported

   b. Code generation of an AC creates proxy ports and proxy properties

   c. The AC is the main component of an application assembly

   d. The AC is generally connected to every component of an application assembly in order to control them

   e. Every time a new component is added in the application assembly, the AC must be changed. The same is true when a new property/port needs to be made external

   f. Maintaining an AC can quickly become a nightmare

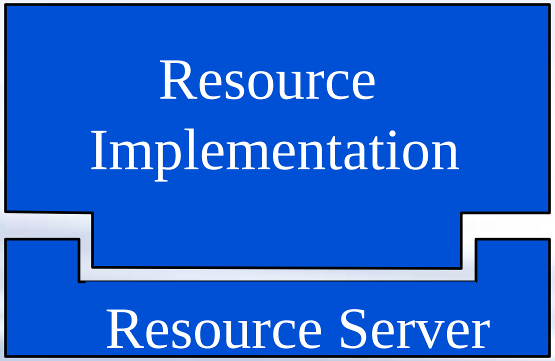
SCA Architect™ – Assembly-Level RAD Features

2. ResourceFactory Modeling and Code Generation

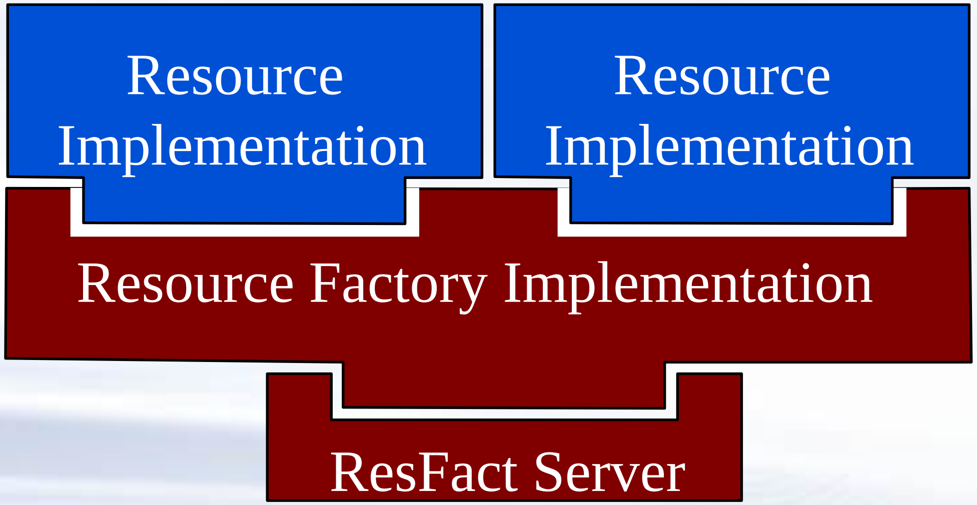
a. Using a wizard, SCA Architect™ can generate a ResourceFactory model from a list of application components:

- Specify which component needs to be deployed by the ResourceFactory
- Doesn’t require a single line code to be changed in the Resources

b. Can be used to optimize footprint and performance of several application components



Standalone Resource



Several Resources Combined

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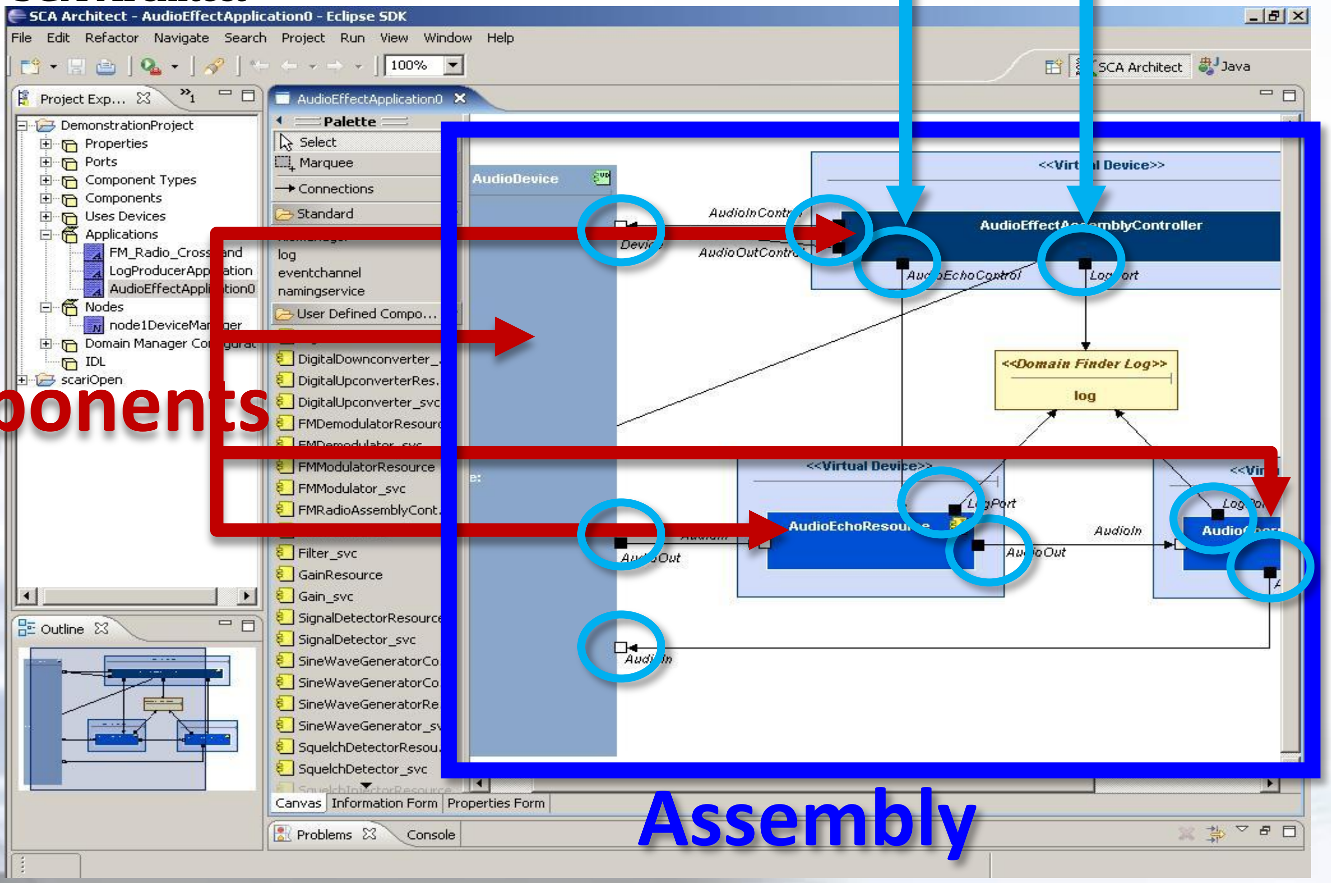
Summary

The SCA is a Component-Based Design architecture

SCA Architect ™



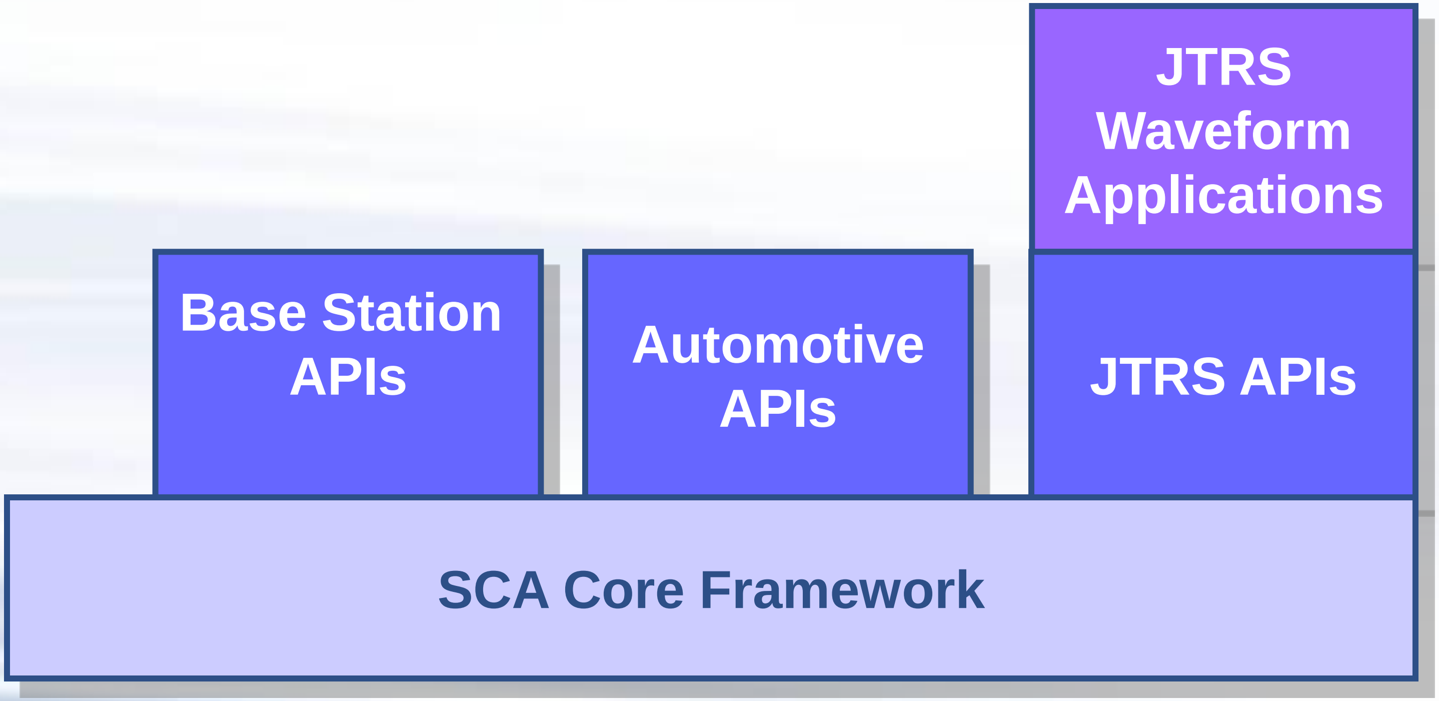
Ports

Components

Assembly

Summary

Without any API supplement, the SCA is not radio nor military specific



JTRS Waveform Applications

Base Station APIs

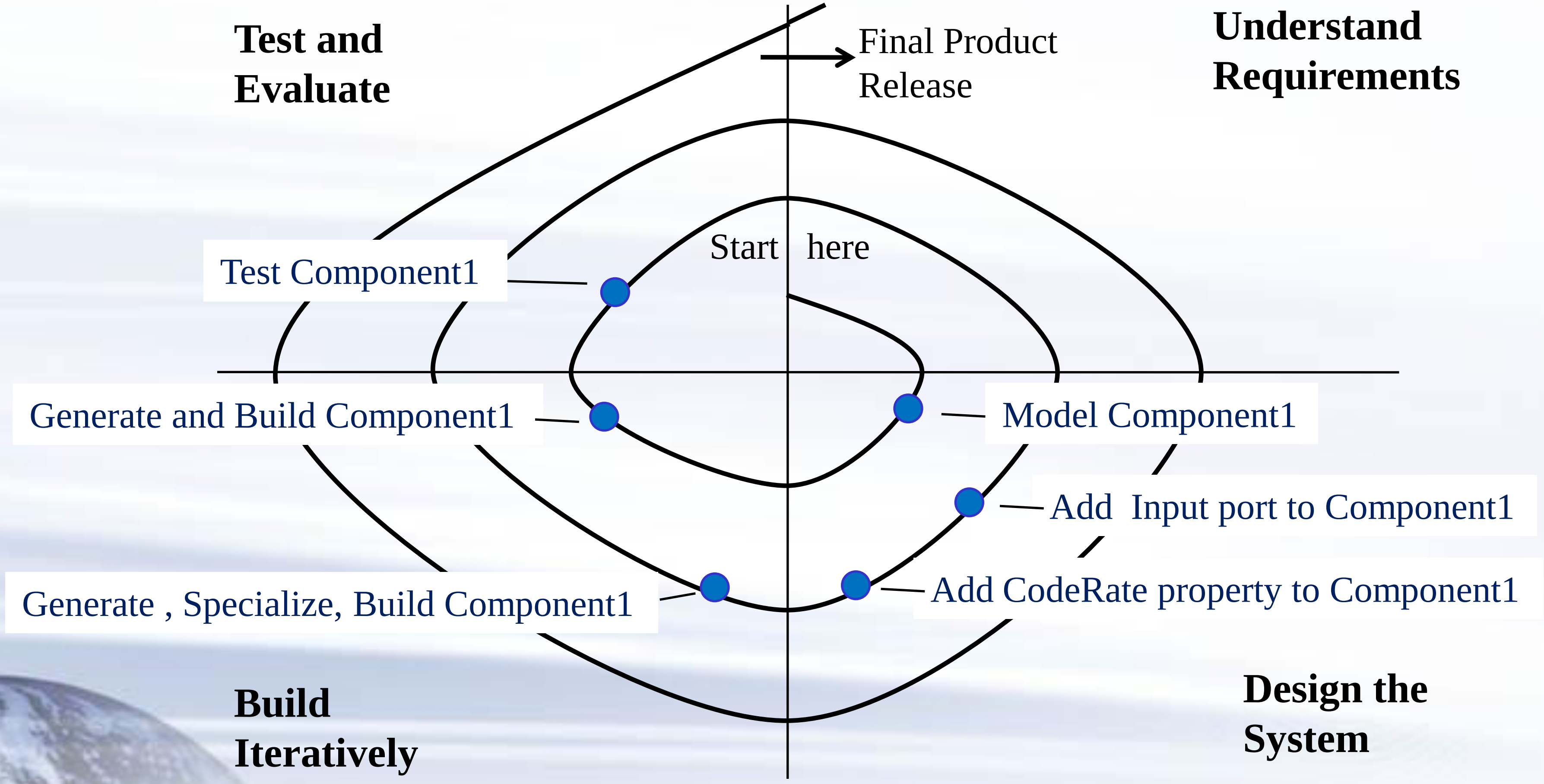
Automotive APIs

JTRS APIs

SCA Core Framework

Summary

Using a RAD tool can definitely make it easier to use the SCA


Test and Evaluate
Final Product Release
Understand Requirements
Start here
Test Component1
Generate and Build Component1
Model Component1
Add Input port to Component1
Generate , Specialize, Build Component1
Add CodeRate property to Component1
Build Iteratively
Design the System

Questions ?

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Web Sites:	http://www.crc.ca/rars http://www.crc.ca/scari