The SCA: Myths vs Reality
Is the SCA what you think it is?

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Outline

1. Overview of the Software Communications Architecture (SCA)
2. Is the SCA too slow?
3. Is the SCA too fat?
4. Summary
1. SCA Overview

• The SCA was developed to assist in the development of SDR for the Joint Tactical Radio System (JTRS). As such, the SCA has been structured to:
  – Provide for portability of applications between different SCA platforms
  – Leverage commercials standards to reduce development costs
  – Reduce software development time with the ability to reuse design modules
  – Build on evolving commercial frameworks and architectures

• The SCA is not a system specification but an implementation-independent set of rules that constrain the design of systems to achieve the above objectives
1. SCA Overview

1. Myth #1: The SCA is only for military Radios
   - While it’s true the SCA specification was developed for the US DoD JTRS program, the reality is the core framework specification contains no military features at all!

2. Myth #2: The SCA is for building Software Defined Radios
   - None of the core framework APIs are radio specific!
   - An SCA platform can host any kind of application
     - radar, medical imagery, test equipment, etc.
1. SCA Overview

- The SCA Core Framework specification (version 2.2.2) is made of five documents:
  - Main document (130 pages)
  - Appendix B – Application Environment Profile (21 pages)
  - Appendix C – IDL (41 pages)
  - Appendix D – Domain Profile (64 pages)
  - Appendix D – Attachment 2 – Common Properties (4 pages)

- Previous releases of the SCA specification had two extra documents named Security Supplement and API Supplement
  - These documents were last published in 2001
  - The security supplement adds RED/BLACK centric APIs
  - The API supplement adds communications/radio centric APIs
1. SCA Overview

- The SCA is application domain independent
- API supplements are domain specific
1. SCA Overview

- The SCA specification describes how to create a platform that can host SCA-compliant applications
  - It describes how a platform makes its devices and services available to applications
  - It also describes how applications are deployed

- The SCA describes an architecture capable of doing what every real-time operating systems does:
  - Load and execute applications
  - Specify priorities and stack sizes for individual tasks
1. SCA Overview

- So what is so unique about the SCA?
  - It is platform independent
    - Supports any operating system*, processor, and file system
  - It is a scalable distributed system
    - Supports single processor applications the same way it supports multi-processor applications
  - An SCA platform can be made of several nodes with different processor architectures running different operating systems supporting different file systems

- The most unique attribute of the SCA is that it’s actually a **Component Based Development architecture**!

* OS must meet a subset of POSIX APIs
1. SCA Overview

• What is Component Based Development (CBD) ?
  – **Definition:** an architecture which allows the creation, integration, and re-use of components of program code
  – CBD is a new development paradigm where the smallest unit of software is a **component**
  – With CBD, an application is ‘assembled’ using **software components** much like a PCB is populated with hardware components

• CBD is a very popular paradigm for application development
  – ‘.Net’ (from Microsoft) and ‘**EJB**’ (from Sun Microsystems) are two very popular CBD architectures
  – The OMG CORBA Component Model (**CCM**) is another example of a CBD architecture
1. SCA Overview

• **Software Component**
  – **Definition:** is a small, reusable module of executable code that performs a well-defined function. It is designed, implemented, and tested as a unit prior to integration into an application
  – It is **not a function** compiled and stored in a static library; it’s executable code which provides a service

• **A software component is a “black box”**
  – Application designer is concerned with what a component does, not how it does it
  – Creating an application requires component assembly-level information; the equivalent of a “spec sheet”
    • With the SCA, this information is located in a database called the “domain profile”
1. SCA Overview

- Here’s an example of a component assembly
  - FM modulation application
1. SCA Overview

• **How is the SCA different as a CBD?**
  – As opposed to **EJB**, the SCA supports native components
  – As opposed to **.Net**, the SCA is platform-independent
  – As opposed to **CCM**, the SCA is device-centric
    • Provides fine control over the deployment of components

• **With the SCA, a software component can be packaged with several implementations**
  – Each implementation is characterized by **capacity** requirements (run-time memory, mips, channels, etc.) and **capability** requirements (OS, processor, etc.)
1. SCA Overview

- Here’s what the definition of an SCA software component (spec sheet) looks like:

  ![Diagram showing the structure of an SCA software component]

  - **encoder.prf.xml**
    - CodeRate: double
  - **Encoder_vxw.a**
  - **Encoder_linux.a**
  - **Encoder_win.exe**

  **encoder.spd.xml**
  - Component Descriptor
  - Property File

  **encoder.scd.xml**
  - Implementation 1
  - Implementation 2
  - Implementation n

  - InPort: OctetProducer
  - OutPort: OctetConsumer
1. SCA Overview

• In summary, the SCA is a Component Based Development architecture which is platform-independent and device-centric

• The SCA is **not** specific to SDR or military applications
Outline

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2. Is the SCA too Slow?

- In order to measure the speed of the SCA, let's look at different common use cases for an SCA platform:
  - Use Case 1: Booting an SCA platform
  - Use Case 2: Installing an application
  - Use Case 3: Running an application

- Use Case 1 involves starting a number of SCA components
  - Starting software components means creating a number of process/tasks
  - This is not unique to the SCA, it's required for any SDR platform
  - How fast can your RTOS create/spawn a process/task?
  - How fast can application artifacts be copied from storage memory to run-time memory?
2. Is the SCA too Slow?

- Use Case 2 involves loading all the artifacts associated with an application into storage memory of an SCA platform
  - Again, this is not unique to the SCA
  - Depends on the speed of the bus/memory and the size of the artifacts
  - Installation of an application is typically done at the factory when time is not very critical
2. Is the SCA too Slow?

- Use Case 3 involves starting application software components
  - A target device must be chosen for each component
    - This may take some time, but the SCA offers a way of avoiding run-time decisions
  - The chosen implementation for each component must be loaded into the runtime memory of the target device
    - Depends on the speed of the bus/memory
    - This can be an issue; not unique to the SCA
    - Better SCA implementations can alleviate this problem
2. Is the SCA too Slow?

- **Use Case 3 also involves data processing**
  - SCA application components must communicate with each other to perform signal processing
  - With the SCA, communications are normally implemented using CORBA
  - Application throughput is therefore limited by CORBA
  - How fast is CORBA?
2. Is the SCA too Slow?

- **CBD requires inter-process communications (IPC) to allow components to interact**
  - A software component can run as a process or task
  - Cannot assume components always run in a process

- **The SCA mandates the use of CORBA as the primary form of communications between software components**
  - CORBA is very scalable and provides a single model for component communications
    - Communications APIs are the same whether components are across the network, on the same board, or in the same process
  - CORBA is COTS
2. Is the SCA too Slow?

- CORBA supports several IPC mechanisms
- However, most commercial CORBA products are implemented using the Socket IPC mechanism for TCP/IP
2. Is the SCA too Slow?

- **Myth #3: CORBA is slow!**
  - The speed of communications between components is directly related to the IPC mechanism being used
  - Using TCP/IP can be slow and it’s often a bad choice for embedded systems
  - In reality: CORBA is NOT slow but TCP/IP can be.

- **Real-time CORBA products typically support several IPC mechanisms**
  - UDP, Multicast, Shared Memory, etc.
  - Developers can add support for other IPC mechanisms
2. Is the SCA too Slow?

• Using a Real-time ORB makes a great difference!
  – For instance, ISR Technologies manufactures an SCA radio which comes with two applications: Voice over IP and Video
  – Using the ORBexpress (i.e. CORBA) and the INTCONN IPC, they were able to lower the ping delay between two radios to \(~10\mu\text{sec}\) vs \(~300\ \mu\text{sec}\) for TCP/IP
2. Is the SCA too Slow?

- **Is CORBA slow?**
  - The real question is: *How fast is your IPC mechanism?*

- **If there’s an IPC mechanism that’s fast enough for your application, then you should use CORBA!**
  - no learning curve for the IPC
  - Provides IPC independence
    - if a new and faster IPC becomes available, you can use it without changing any source code

- **Conclusion:** The SCA is as fast as the CORBA product being used
  - The SCA does not get involved in the communications between application components; only CORBA does!
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3. Is the SCA too Fat?

• Here’s a block diagram of an SCA platform

```
+---------------------------------+
| SCA Applications                |
|+S-----------+--------------------------+|
| SCA CF + SCA Devices/Services  |
|POSIX AEP                     |
+-------------------------------+  |
| Device Drivers                |
+-------------------------------+  |
| Operating System              |
+-------------------------------+  |
| Processor                     |
```

• The SCA requires an operating system capable of loading new code dynamically
  – Many SDRs only use a simple scheduler/kernel which only supports static images
  – Essential to support new applications without rebooting
3. Is the SCA too Fat?

- **The SCA does not require just any OS**
  - OS must provide a subset of the POSIX APIs
  - Essential to enhance application portability

- **The SCA Core Framework**
  - Provides platform control
    - Install/launch applications
    - Start node components to gain access to devices
  - Requires an XML parser
    - Xerces-C++ requires 2.6 MB of static footprint and typically around 4 MB of dynamic footprint
  - Requires CORBA generated code
    - Static footprint: 750K (ORBexpress) or 3.3 MB (TAO)
3. Is the SCA too Fat?

- **SCA Application**
  - Is an assembly of several software components
  - Each component requires CORBA generated code
    - Static footprint: 730K for ORBexpress or 3.3M for TAO

- **Quantifying the footprint requirement for an SCA radio is difficult**
  - Is directly related to the number of software components required by the platform and the applications
  - Currently, a full featured SCA CF and a node with a couple devices and services will require around 25 MB of footprint
    - The Xerces-C++ XML parser will use ~40%
    - CORBA generated code ~30%
3. Is the SCA too Fat?

• The CRC AudioEffect demonstrator runs in ~50 MB of total footprint
  – Embedded Planet PPC405 board (EP405), 128MB RAM
  – CRC’ SCARI++ CF for INTEGRITY/ORBexpress
  – Node description:
    • Full featured DeviceManager
    • ExecutableDevice
    • Log service
  – Application with 3 components which perform Echo and Chorus effect on an input voice signal
  – Xerces-C++ XML parser
  – INTEGRITY Kernel with POSIX and VFS/NFS support
  – ORBexpress Name Service
3. Is the SCA too Fat?

- The ISR JTRS Demo Set requires ~51 MB of total footprint
  - VoIP 256 Kbits/s BFSK, Video Waveform 1024 Kbits/s BFSK
  - Xilinx Virtex-4 FPGA, 128MB RAM
  - CRC’ SCARI++ CF for INTEGRITY/ORBexpress
  - Node description:
    - DeviceManager, DDCDevice, DUCDevice, EthernetDevice, FGPAExecutableDevice
  - 2 SCA applications of 2 components each
  - Xerces-C++ XML parser
  - INTEGRITY Kernel with POSIX and VFS/FFS support
  - ORBexpress INTCONN support
  - ORBexpress Name Service
3. Is the SCA too Fat?

• **Is the SCA is too fat?**
  – Reality: the SCA can be large for a small form factor SDR which will never be upgraded post-manufacturing
  – Won’t fit on a cell phone…yet!

• **SCA CF Implementations can be made “lighter” while maintaining compliance with the SCA**
  – Its just a question of time…
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• The SCA is a Component Based Development architecture
  – Not specific to military SDR
  – Can be used for any embedded application

• The SCA can be slow
  – Using a Real-Time CORBA product is essential

• The SCA footprint is reasonable and will improve with time
  – 64 MB is enough for many platforms
  – The SCA can be made smaller without having to change the specification
Questions ?
SCARI++ Software Suite

• CRC offers the most complete solution for SCA development
  – Development tools
  – Monitoring tools
  – Core Framework
  – Training
  – Consulting
  – Certification expertise
• Team has over 6 years of SCA experience
  – CRC trained companies from around the world
  – CRC helps companies to gear-up for the SCA market

• CRC’s SCARI++ Core Framework is available for the most popular operating system and processors

• CRC will soon offer a completely new Eclipse-based Integrated Development Environment (IDE)
 CRC offers an complete Integrated Development Environment (IDE) for the SCA
  – Core Framework Independent

 Implements real-time model validation; prevents you from creating invalid XML descriptors
  – Validation messages are hyperlinked to models

 Provides model re-factoring capabilities
  – Common model validation errors can be fixed through suggested re-factoring

 Can reverse-engineer models for existing components

 CRC’s development tools have been designed with an intimate knowledge of the SCA specification
• **Based on the widely adopted Eclipse framework**
  - Provides platform independence (Windows, MAC, Linux, etc)
  - Every major vendor of the embedded domain support Eclipse
  - There is a enormous number of plug-ins to choose from to help with every aspect of software development (code authoring, documentation, unit test, configuration management, UML, etc.)

• **Simplifies Configuration Management**
  - Perform CM tasks at the model level instead of at the artifacts level
SCARI++ CF Highlights

- CRC also provides a Core Framework: SCARI++
  - Built from the ground-up for embedded platforms
  - Implementation of the SCA version 2.2
  - Very portable POSIX implementation
  - Implemented with lessons learned from the JTRS Certified SCARI Core Framework
  - Comes with a POSIX Executable Device, an AudioDevice and demo applications
• Provides extra APIs for introspection
  – Optimized way of obtaining deployment information
  – Can show established connections during run time

• Supports the deployment of components on standalone remote Devices
  – Devices can be started manually and report to a remote DeviceManager

• Allows Devices to be collocated in a same address space
  – Dramatically increase rate of communications between Devices
• Transparently optimizes connections so they can be performed as fast as possible
  – Indirect connections are transformed into direct connections which requires much less CORBA interactions

• Supports orderly shutdown of devices even when running applications
  – A Device can be released or killed while it is running an application
SCARI++ CF Highlights

• Available for different operating systems:
  – INTEGRITY
  – VxWorks
  – Linux
  – Yellow Dog
  – and soon for LynxOS

• Available for different ORBs:
  – ORBexpress
  – TAO