Success Oriented Ground and Space Software Defined Architectures

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Introduction

- Software Defined Radio (SDR) Architectures Background
- JTRS/SCA Terminology
- SCA Software Structure
- Example Ground SDR
- Example Flight SDR
- Successful Architecture Attributes
- Conclusions
JTRS/SCA Terminology

- **Joint Tactical Radio System (JTRS):** A radio system within the 2MHz to 2Ghz (tactical) frequency range and has the SCA infrastructure (see below).

- **Software Communication Architecture (SCA):** The underlying infrastructure specification that must be implemented.

- **Core Framework (CF):** The realization of the SCA specification that provides the radio infrastructure services specified in the SCA.

- **SCA-Compliant:** A radio that has a Core Framework that adheres to the SCA is SCA-Compliant.

Both radios are SCA-Compliant
SDR Abstraction

- Dynamic (re)configurability
  - Components
  - Waveforms
  - Processing paths
- Plug-n-Play components
- Reuse of common implementations
- The Framework or Infrastructure provides the intelligent abstraction away from the physical implementation
- The Framework provides the foundational technology for realizing a cognitive radio.

Waveform Implementation Paths

- Waveform Specification
- C/C++
- VHDL
- Framework/Infrastructure
- Operating System
- GPP
- DSP
- FPGA
- Host Platform
SCA Software Structure

Assured Communications™

Core Framework (CF)

Commercial Off-the-Shelf (COTS)

Non-CORBA Components

Modem

Link, Network

Security

Operating System

Network Stacks & Serial Interface Services

Board Support Package (Bus Layer)

Black Hardware Bus

Red Hardware Bus

Logical Software Bus (CORBA)

CORBA ORB & Services (Middleware)

CF Services & Applications

Operating System

Network Stacks & Serial Interface Services

Board Support Package (Bus Layer)

Logical Software Bus (CORBA)

CORBA ORB & Services (Middleware)

CF Services & Applications

Operating System

Network Stacks & Serial Interface Services

Board Support Package (Bus Layer)
RTOS and Core Framework

- Real-Time Operating System (RTOS) Must Support the SCA Application Environment Profile (AEP)
  - The SCA AEP is a subset of the POSIX.13 Real-time Controller System Profile (PSE52)
  - Can be fully POSIX Profile 52 (or greater) compliant

- Applications shall be limited to using the RTOS services that are designated as mandatory in the SCA AEP

- The Core Framework implements a essential functionality of the SCA
SCA Concept Hierarchy

- **Application** – The top-level entity used by the radio operator, i.e., waveform.
- **Components** – Software units that provide specific functionality either directly or through underlying hardware.
- **Resources** – An abstraction of the type, capacity, and state of a logical entity.
- **Devices** – The collection of physical elements comprising the radio system.
Various Typical SCA Compliant Operating Systems and Platforms

- **SCA 1.1**
  - VxWorks / Pentium / ORBexpress GT 2.1.4
  - VxWorks / PowerPC / ORBexpress GT 2.1.4
  - VxWorks / StrongARM / ORBexpress RT 2.3.1A-β
  - LynxOS / PowerPC / ORBexpress GT 2.1.4B-β
- **SCA 2.2**
  - Windows / Pentium / ORBexpress RT 2.3.5
  - Windows / Pentium / ACE-TAO
  - VxWorks / PowerPC / ACE-TAO
  - Linux / Intel / ACE-TAO
  - VxWorks / PowerPC / ACE-TAO (OCI)
  - Windows / Intel / ACE-TAO (OCI)
Domain Management

Domain Modeler

- Constraint Engine
- Domain Modeler
- XML Domain Profile

Run-Time Monitor

- COM/CORBA Bridge
- Run-Time Monitor
- XML Processor

Run-Time Environment

- Device Manager(s)
- Device
- Device
- Device
- Device
- Chassis
- RF Amplifiers
- Device
- Device
- Device

dmTK Core Framework

- Framework Services (Log, Event, and Name)
- Application Factory
- Constraint Engine
- XML Processor

CORBA Infrastructure

- Domain Manager
- Domain Knowledge
- Waveform Application
Software Definable Features for Space and Ground Architectures

- **Modulation Modes** – FSK, MSK, QPSK, OQPSK, SQPSK, SOQPSK, DPSK, SFDPSK, GMSK
- **IF Interfaces** – 70 MHz, 140 MHz, 700 MHz, L-Band 950 to 2050 MHz
- **Data Rates** - 9600 bits/second to 1 Gbit/sec basecard
  - Multiple Systems Supported
- **Forward Error Correction Coding**
  - Turbo (Rate 2/3, 3/4)
  - K=7 Convolutional (Rate 1/2)
  - Reed Solomon
  - Turbo (other rates)
- **Other Specialized Functions**
  - Bit Count Integrity
  - Mux/Demux for In-Band Control
  - Data Scrambling
  - Differential Encoding
  - Interleaving/ De-interleaving
  - Phase ambiguity resolution
- **Interfaces**
  - Control and Status
  - Local and Remote Operator
  - Ethernet, RS-232, RS422, RS485

Algorithms are loaded and executed in programmable devices
Processor basecard supports a modulator/ demodulator application
Transmit or receive IF modules at different frequencies mount on the CCA
Customized mezzanine I/O modules provides maximum flexibility
SCA Compliant Programmable Modem Meets SDR Needs

- **SCA Device and Device Manager interfaces capabilities include:**
  - Device Manager interface for the board
  - SCA File System interface for on-board flash
  - Logical Device interface for each FPGA and the DSP
- **Demonstrated SCA and SDR Programmability Capabilities**
  - Legacy compatibility
  - Control of external components (video for example)
  - Shutdown of TCDL waveform, load, and start of CDL waveform accomplished in under 10 seconds
Typical Ground SDR Base Card Structure
Modem SCA Architecture

Manage onboard flash memory as an SCA File System. Allows external access into the flash by 3rd party software.

DSP and FPGAs are represented as discrete SCA Devices providing a fine-grained management and control capability.

Base card is represented as an SCA Device Manager. This maps to the use of the File System for flash and multiple devices on the card.

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SDR Flight Processor Requirements Derived from the Ground Basis

- Multiple FPGAs
  - Maintain identical pin-out on all devices
    - Simple configuration creation/partitioning
  - High Speed Communication busses
  - Single Microprocessor Interface
  - Independent banks of memory per FPGA
  - Built in Test for fault detection, some isolation, of assembly
    - Configuration
    - Opens
    - Shorts
    - Signal integrity
  - Implement a SEU detection scheme for configuration bit streams

These Requirements Support Successful in-Flight Software Programmability
Typical Space SDR Base Card Structure

Flight Architecture Builds Directly from the Ground Architecture
Successful Ground and Space Architecture Attributes

- Programmability is built-in from the start
- SCA compliance stems from a cohesive development and run-time environment design methodology
- SDR programmability must be accomplished seamlessly and in minimum time
- Space SDR platforms build directly from sound ground SDR architectures and features
- Joint optimization of ground and space architectures lead to a successful, truly programmable Ground/Space system
Conclusions

• Software defined implementations provide more opportunity across multiple platforms and maximize design reuse
• Reuse applies not only at multiple levels within an implementation, but across domains such as from ground to space
• Common open architectures deliver designs amenable to improvements by multiple parties
• Overall, SDR implementations provide substantial benefits and lead to successful ground and space communications architecture