Mapping the SCA to Embedded Platforms

Using the SCA with DSPs and FPGAs

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Outline

• SCA Deployment Basics
• Software Defined Radio Hardware
• Mapping the SCA to a Software Defined Radio
  – ExecutableDevice
  – LoadableDevice
• Conclusion
SCA Deployment Basics
Software Components

- SCA component is reusable binary code that performs a well defined function

- SCA Components are modeled as having ports to allow data flow and/or control

- SCA Component are modeled as having properties that can change their behaviour
Software Components (cont.)

• Typical graphical representation of a SCA component:
SCA applications

- SCA applications are composed of software components and connections

![Diagram of SCA application components](Image)

- Audio Device
- cvsd_encoder
- fm3tr_encoder
- msk_modulator
- USRP Device

SCA application
SCA Platforms

- SCA platforms are made of software components called SCA *Devices* used as proxies to hardware components
SCA Application Deployment

• *LoadableDevices* and *ExecutableDevices* are containers for software deployment
  – Used for loading and/or running software

• *Devices* advertise properties while application components specify requirements
  – Capacity properties (MIPS, RAM, etc.)
  – Capability properties (OS, processor, etc.)

• Deployment of an SCA application is a matching process
  – Requirements versus Advertisements
SCA Application Deployment

• SCA application components are deployed to *LoadableDevices* or *ExecutableDevices*

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**Diagram:**
- **Audio Device**
  - cvsd_encoder
  - fm3tr_encoder
  - msk_modulator

**USRP Device**
Software Defined Radio Hardware
SDR Platforms

- SDR platforms can provide three types of Computational Elements (CEs):
  - General Purpose Processor (GPP)
  - Digital Signal Processor (DSP)
  - Field-Programmable Gate Array (FPGA)
Computation Elements

• **Field Programmable Gate Array**
  – Special purpose device used to implement complex logical circuits evaluated in parallel
  – SDR: Used for very fast and highly specialized RF/IF signals processing
  – Popular FPGAs:
    • Xilinx’s Virtex family
    • Altera’s Stratix family
Computation Elements (cont.)

• Digital Signal Processor
  – Special purpose processing unit designed for high speed arithmetic and high data throughput
  – SDR: typically used for baseband/IF signals processing
  – Popular DSPs:
    • Texas Instrument’s C6000 family
    • Freescale’s StarCore family
Computation Elements (cont.)

• **General Purpose Processor**
  – The “Jack of all trades, master of none” processor
  – SDR: GPP typically used for implementing MAC/networking layers
  – Popular GPPs:
    • Intel’s x86 family
    • AMD’s Kx family
    • FreeScale’s PowerQuicc family
Mapping the SCA to a Software Defined Radio
Mapping the SCA to a SDR

- How can the SCA concepts be mapped to a Software Defined Radio platform?
  - SCA models in terms of application components being deployed to SCA Devices
  - While SDR platforms are made of Computational Elements that can be programmed
Basic SCA Devices

- **Device:**
  - Capacity model
  - Cannot load anything

- **LoadableDevice:**
  - Can be used to load files (bit streams, executable code, etc)

- **ExecutableDevice:**
  - Can be used to create multiple tasks
ExecutableDevice
**ExecutableDevice**

- The *ExecutableDevice* is used to represent a Computational Element capable of running several software components concurrently
  - Able to run new binary code without rebooting

- **In short**
  - Requires the support for **multi-tasking**
  - Requires the support for **incremental loading**
**ExecutableDevice (cont.)**

- **Multi-tasking**: method by which multiple tasks (also known as processes) share a single Computational Element
  - Used to run several software components concurrently
  - Usually requires a task scheduler

- **Incremental loading**: method by which new executable code (e.g. components) is loaded into main/execution memory during runtime
  - Implies the use of a loader
    - Usually requires a file system
ExecutableDevice (cont.)

- **GPP:** can be mapped as an *ExecutableDevice*
  - GPP Operating Systems always provide a loader
  - CRC’s *ExecutableDevice* has been used as a proxy to processors such as x86, PPCs, ARM9, and Xscale using INTEGRITY, VxWorks, LynxOS, Linux, and soon Windows

- **DSP:** can be mapped as an *ExecutableDevice*
  - Some DSP Operating Systems provide a loader along with multi-task support
  - Unaware of any SDR platform mapping a DSP as an *ExecutableDevice*
ExecutableDevice (cont.)

- **FPGA**: can be mapped as an ExecutableDevice
  - An FPGA is in fact a parallel processing Computational Element
    - Provides multitasking without the need for a scheduler
  - Can provide support for incremental loading through ‘partial reconfiguration’
    - Can load new components into a ‘running’ FPGA without rebooting
  - CRC helped ISR Technologies support a Xilinx Virtex FPGA with partial reconfiguration using an ExecutableDevice (IDP-100 platform)
LoadableDevice
LoadableDevice

• Used to represent single-load devices
  – No incremental loading capabilities
  – Loading the device will change the device’s behaviour
    • Ex: loading an ‘image’ on a DSP
    • Cannot be used by two applications to load different functionality at the same time
LoadableDevice (cont.)

- **DSP**: are typically used without an operating system
  - This generally means no support for multi-tasking and no support for a loader
  - Once the DSP has been programmed, no new code can be injected without rebooting
  - In such a case, the DSP cannot be mapped as an ExecutableDevice

- **Note:**
  - DSP/BIOS supports multi-tasking but does not provide a loader (and no file system)
LoadableDevice (cont.)

- **FGPA:** is quite often mapped as an SCA LoadableDevice
  - Loads one single bit stream
  - No new code can be injected without rebooting

- **GPP:** is always used with an operating system that provides multi-tasking and a loader
  - Always mapped as an *ExecutableDevice*
Conclusion

• Most current SDR platforms provide all three types of Computational Elements
  – FPGA, DSP, and GPP

• Mapping a Computational Element as an SCA ExecutableDevice requires the support of multi-tasking and incremental loading
  – Many RTOS provide a scheduler for multi-tasking and provide a loader for incremental loading
  – Even some DSP RTOS provide the two characteristics
Conclusion

• Currently, DSPs and FPGAs are generally mapped as a *LoadableDevices*
  – Added complexity for post-manufacturing technology insertion

• For fully flexible Software Defined Radios, Computational Elements should be mapped as *ExecutableDevices*
  – This does not necessarily require the use of a GPP!
Questions?

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