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SDR 2.0 - Entering the Mainstream

Deployment of Software Components into Heterogeneous SCA Platforms

Using the SCA with DSPs and FPGAs

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Outline

- **Reusability through Portability**
- **SCA Deployment Basics**
- **SCA Devices**
- **Computational Elements**
- **Mapping the SCA to a Software Defined Radio**

Reusability through Portability

Reusability Alternatives

- **Implementation Reuse**
 - interpreters or virtual machines
 - binary-compatible family of processors

- **Source Code Portability**
 - Operating Systems (POSIX AEP)
 - Middleware (CORBA, MHAL)
 - Platform Devices (APIs)

SCA

- **Installation, Instantiation and Connection**
 - Core Framework

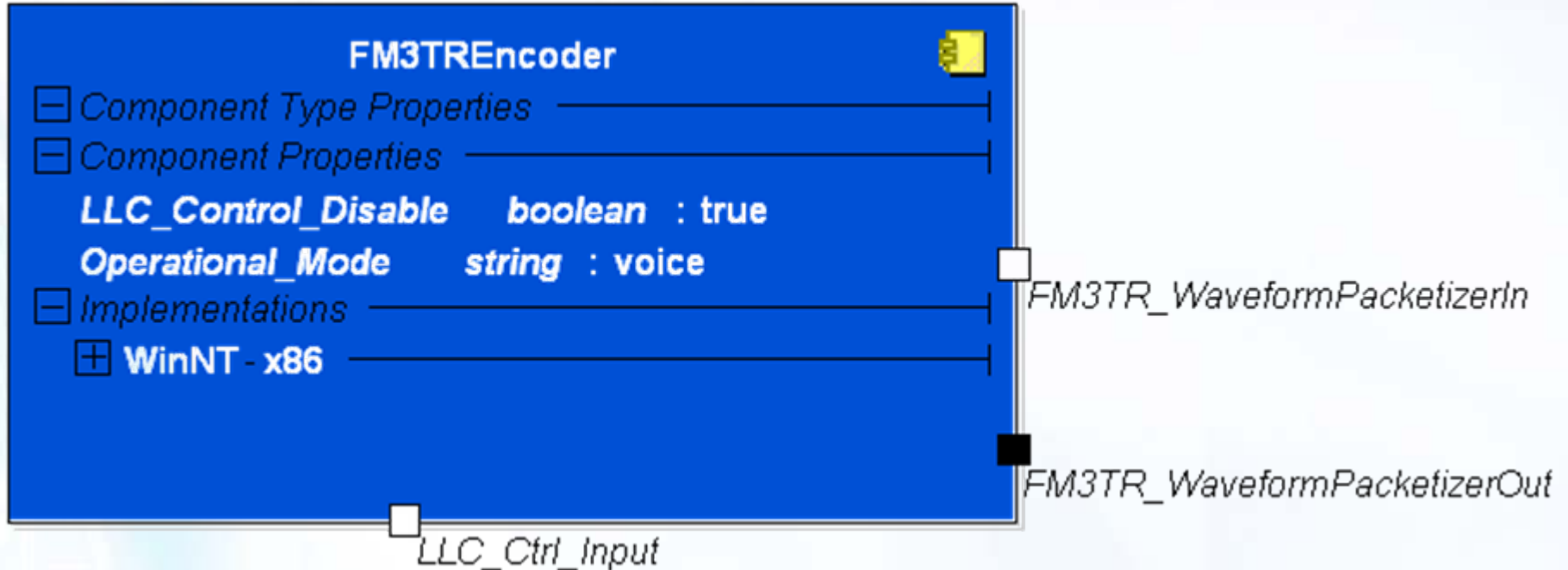
SCA Deployment Basics

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**

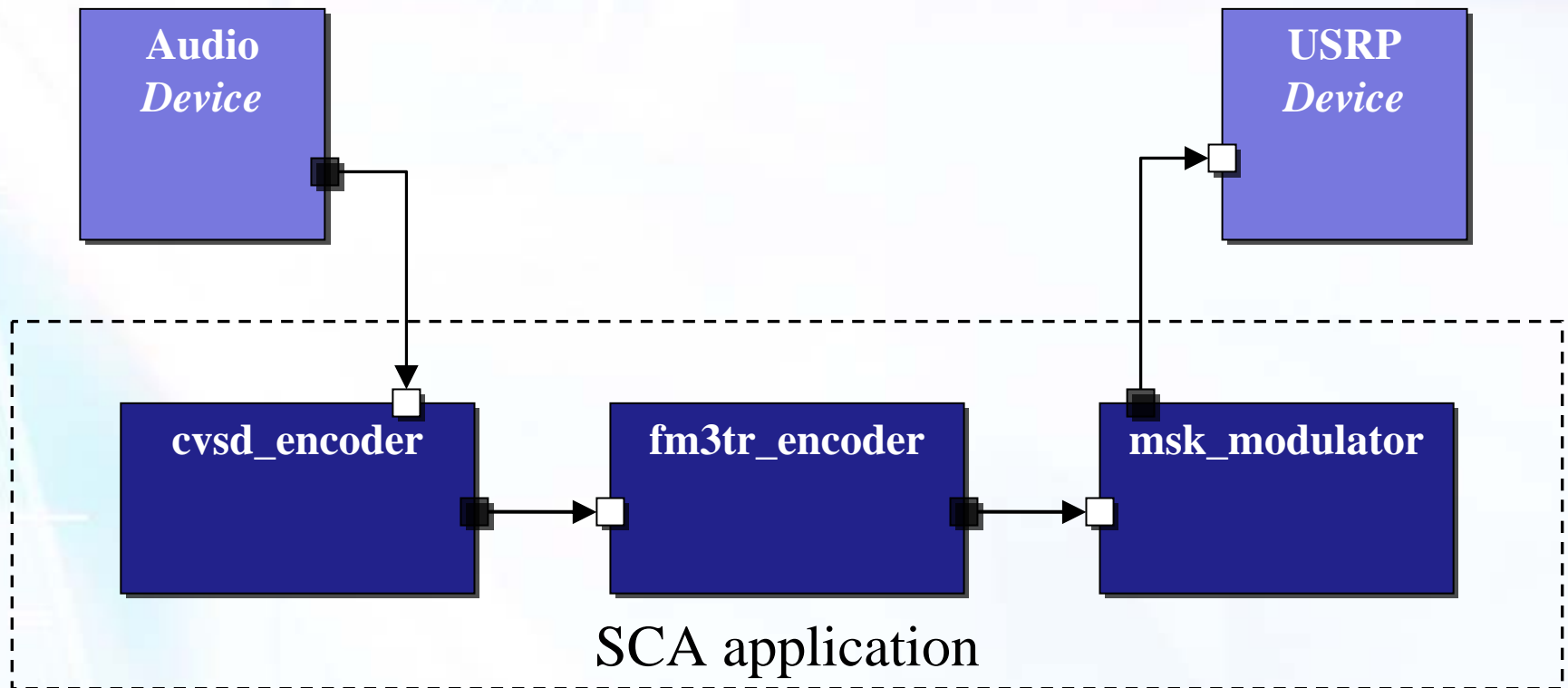
Software Components (cont.)

- Typical graphical representation of a SCA component:



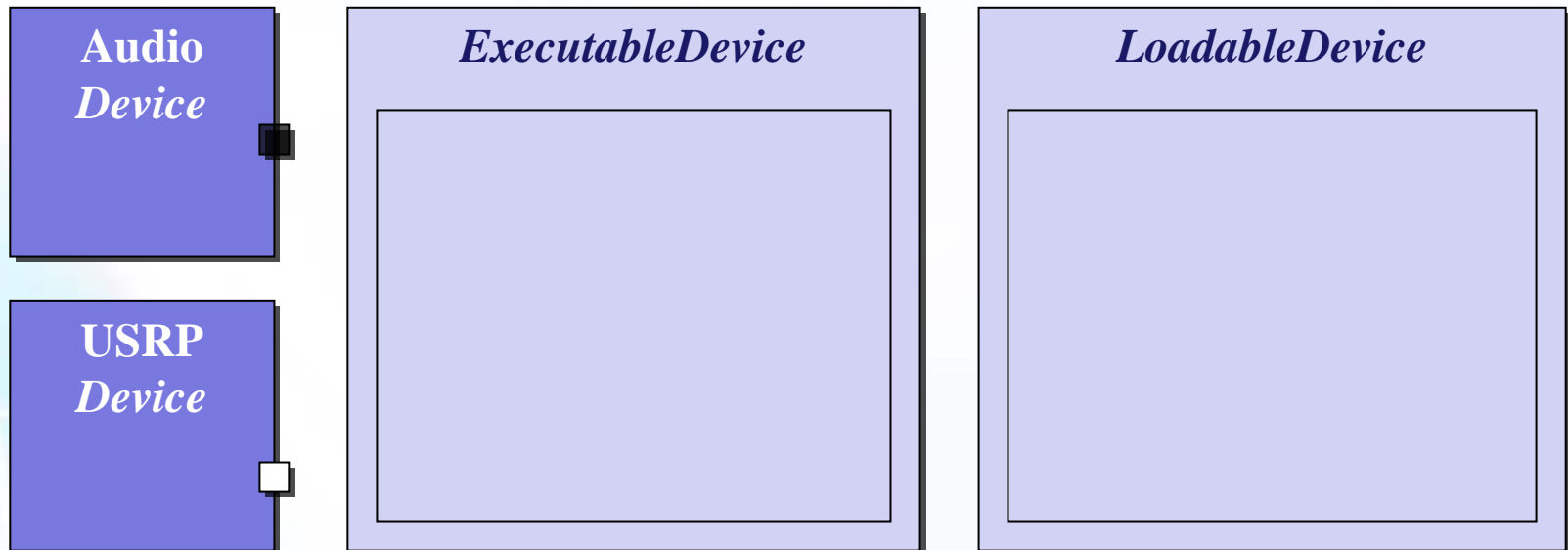
SCA applications

- SCA applications are composed of software components and connections



SCA Platforms

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

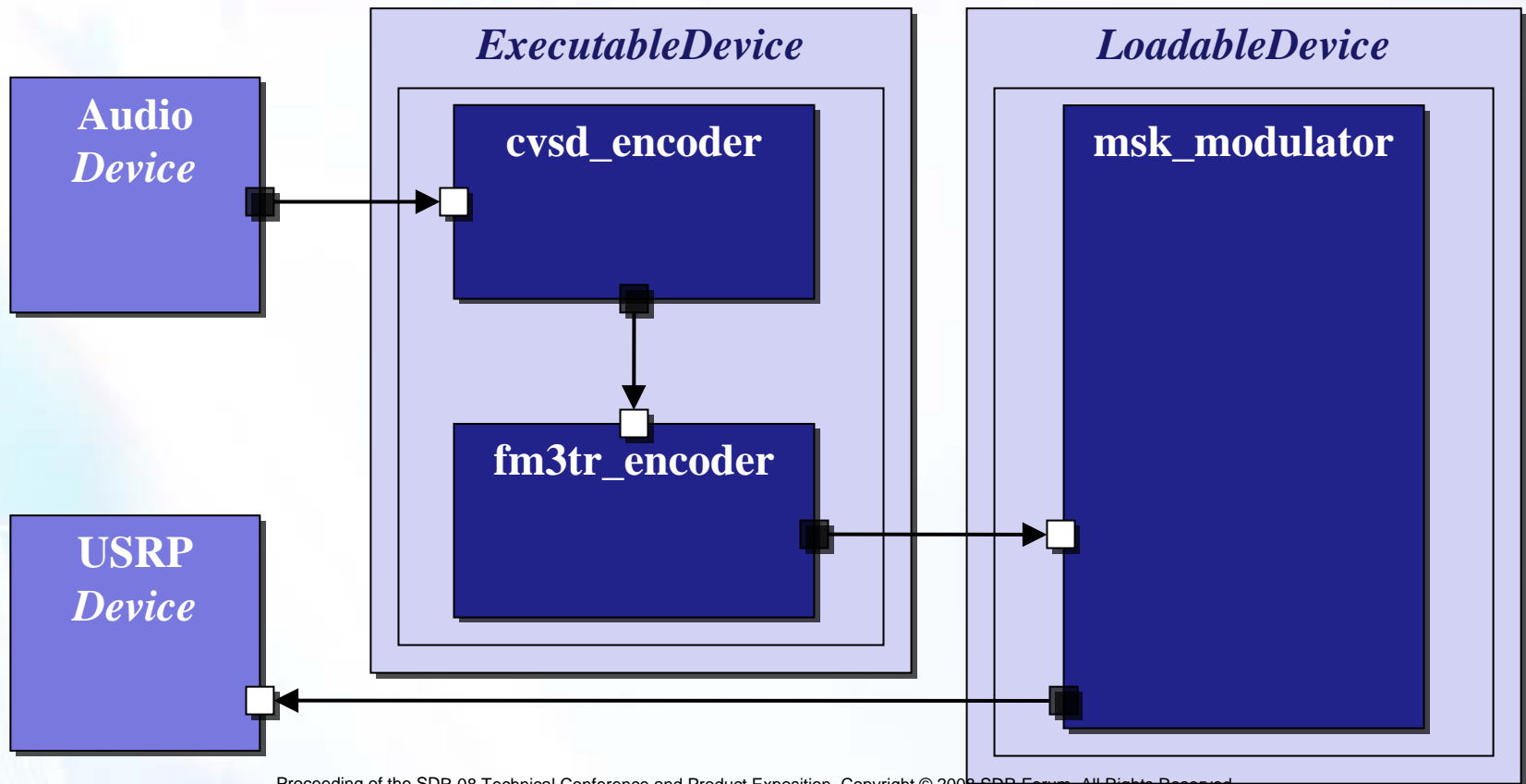


SCA Application Deployment

- ***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

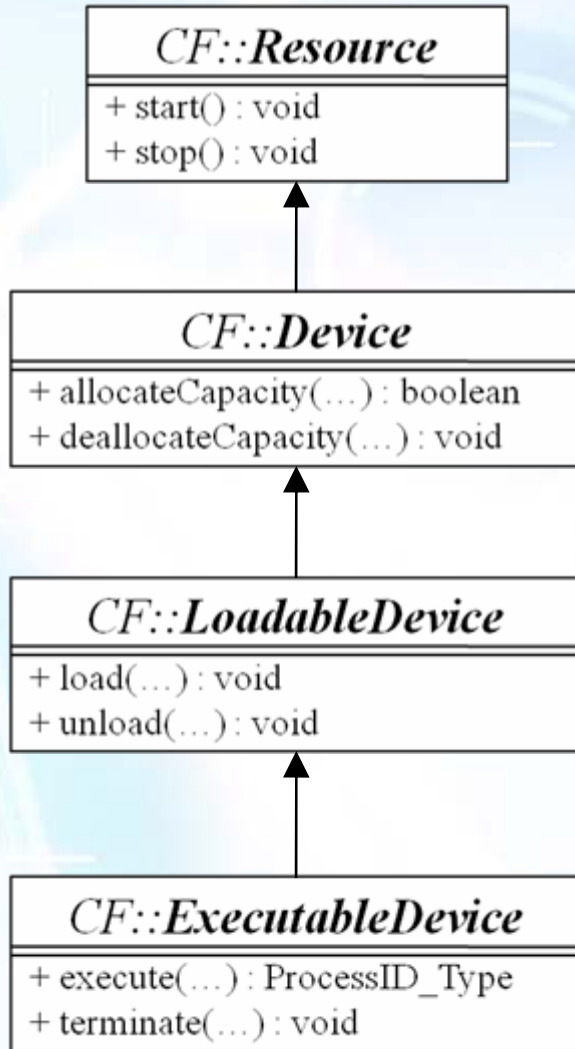
- SCA application components are deployed to *LoadableDevices* or *ExecutableDevices*



SCA Devices

SCA *Devices*

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



SCA Containers

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

LoadableDevice

- **Used to represent single-load devices**
 - Used by the deployment engine to load artifacts of software components.
 - Capable of loading new artifacts, but not capable of launching new tasks (also known as processes)
 - Not capable of instantiating a component.
 - 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

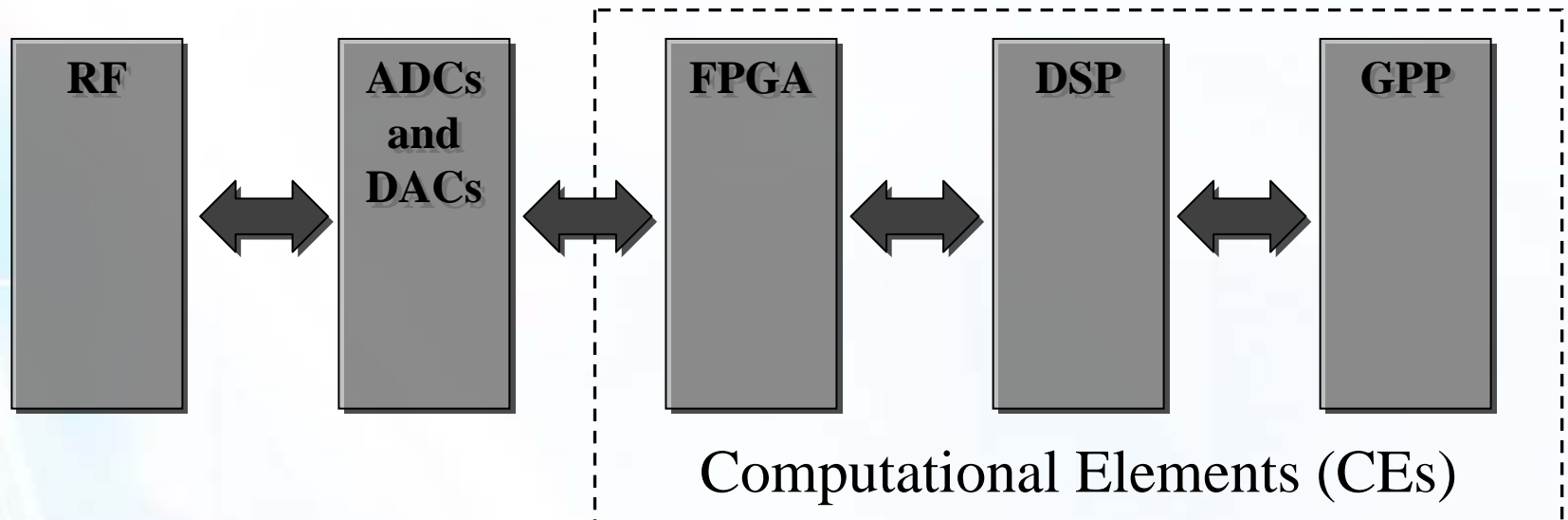
ExecutableDevice

- **Used to represent a Computational Element capable of running several software components concurrently**
 - Used by the deployment engine to load and execute artifacts of potentially many software components.
 - Capable of creating several tasks at the same time without having to reboot to launch a newly loaded task
 - Capable of instantiating a component.

Computational Elements

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)



Computational 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

Computational 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

Computational 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

Key Features

- **Incremental Loading:**
 - Allows new binary code to be loaded into execution memory during runtime without rebooting the CE.
 - Most operating systems that provide this feature do so through what is called a loader (usually requires a file system).
 - For instance, the POSIX standard provides access to a loader through the 'exec()' system calls.

Key Features (cont.)

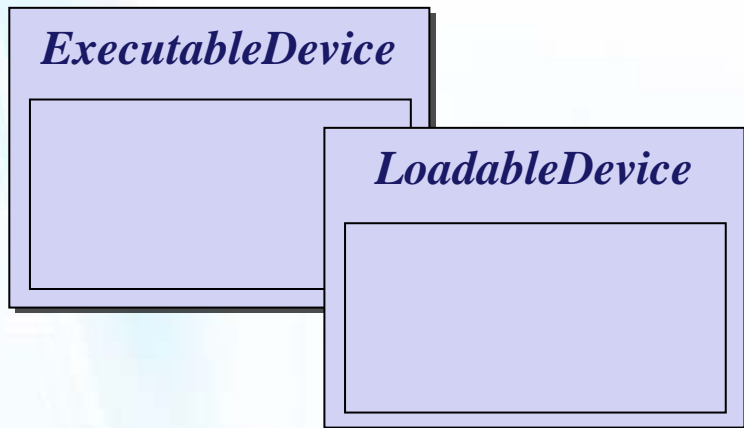
- **Multi-tasking:**

- Allows multiple tasks (also known as processes) to share a single CE.
- Allows several tasks to run concurrently without requiring a reboot every time a new task is launched.
- Most operating systems implement this feature through what is called a task scheduler.

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



ExecutableDevice

ExecutableDevice

- **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

- **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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