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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**

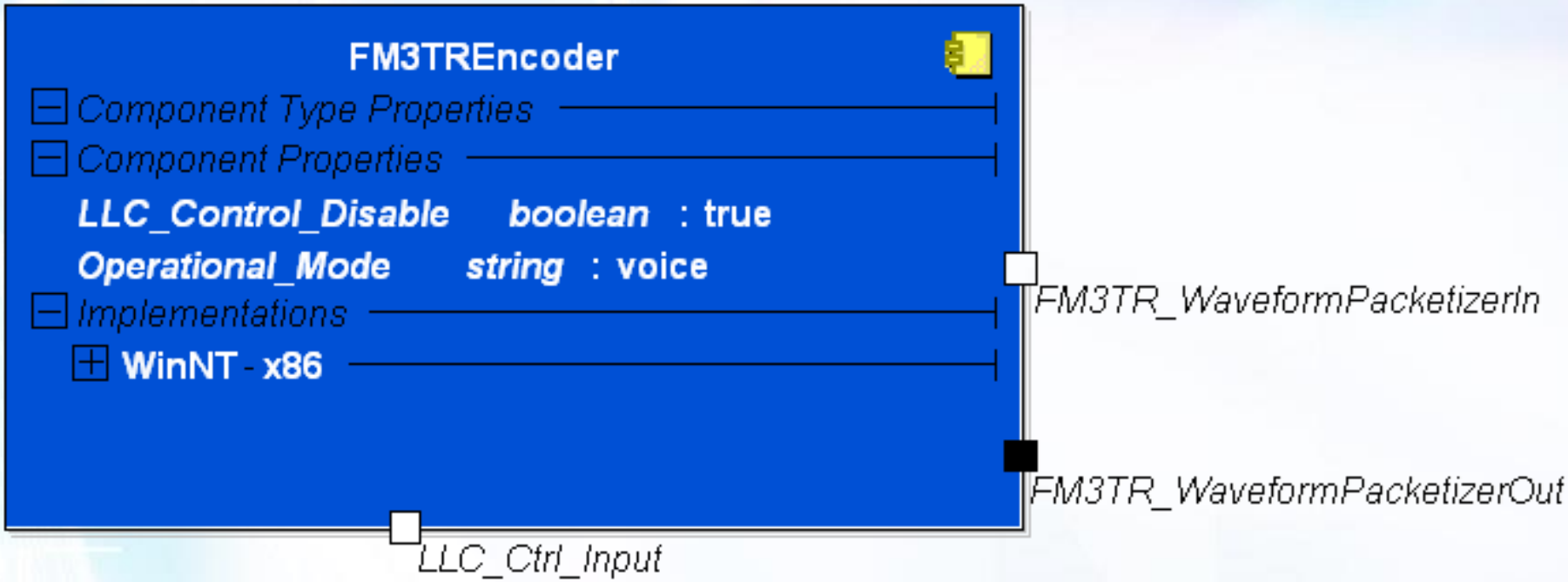
SCA Deployment Basics

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

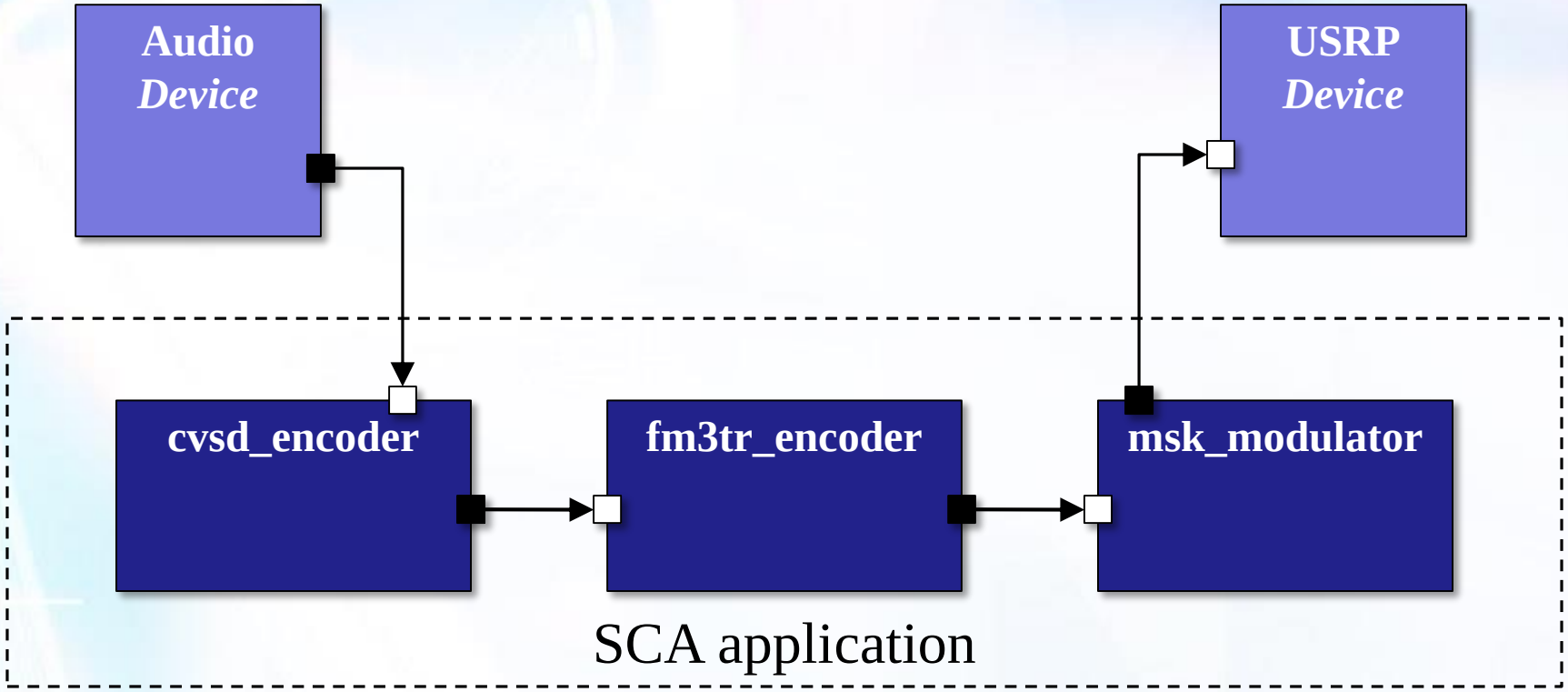
Software Components (cont.)

- **Typical graphical representation of a SCA component:**



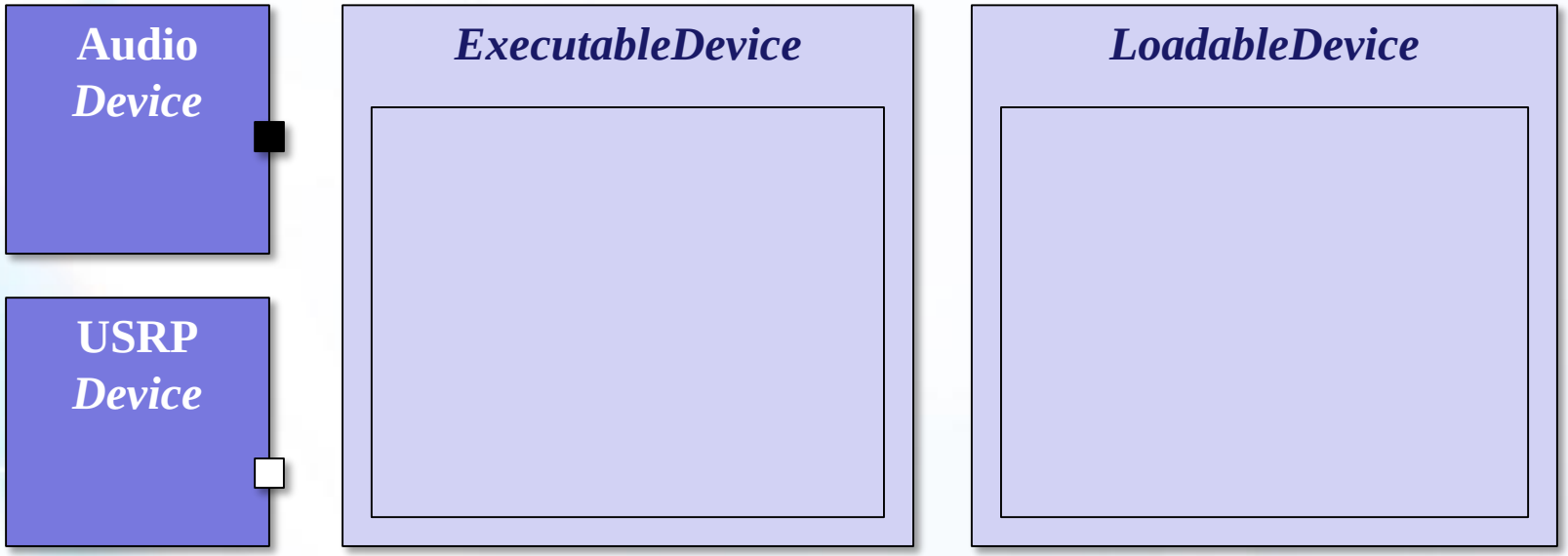
SCA applications

- **SCA applications are composed of software components and connections**



SCA Platforms

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

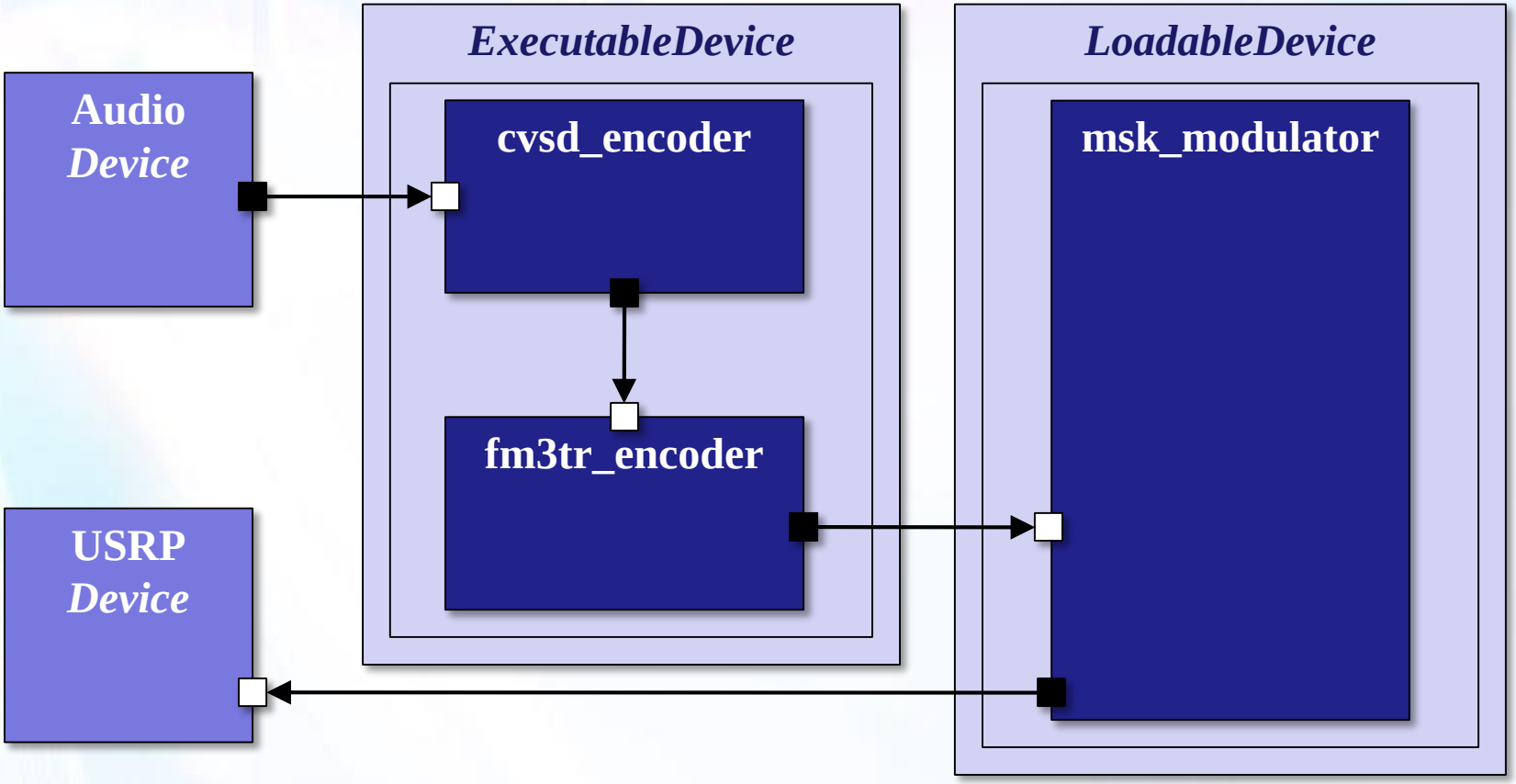


SCA Application Deployment

- ***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

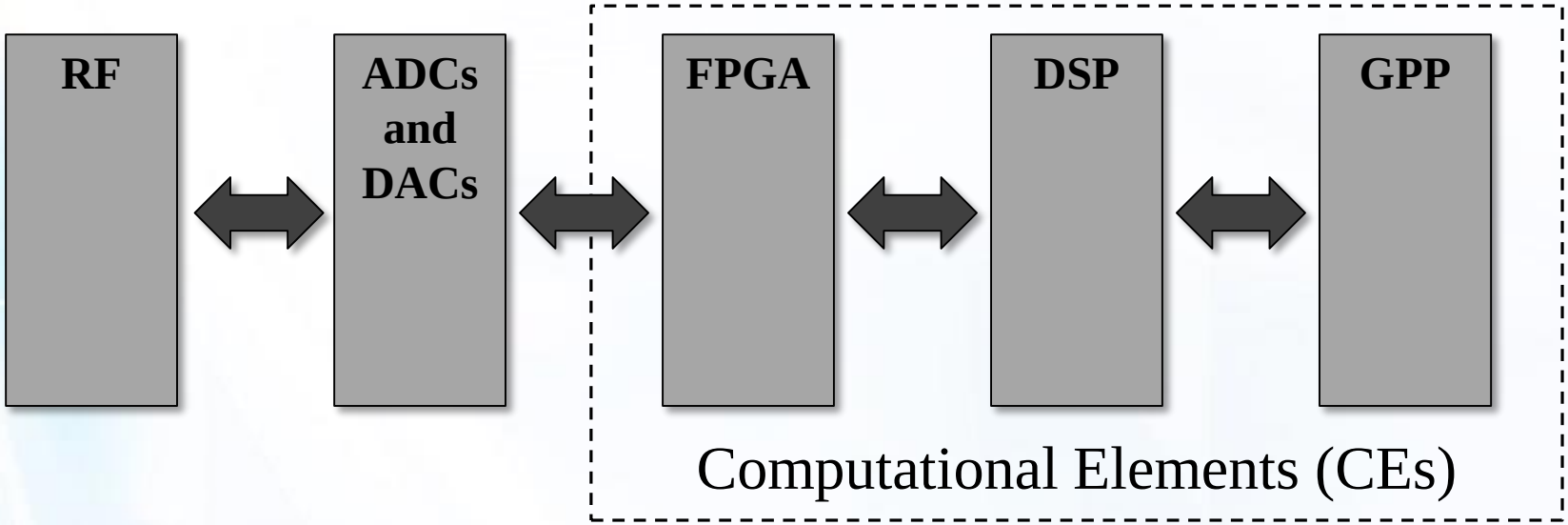
- SCA application components are deployed to *LoadableDevices* or *ExecutableDevices*



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

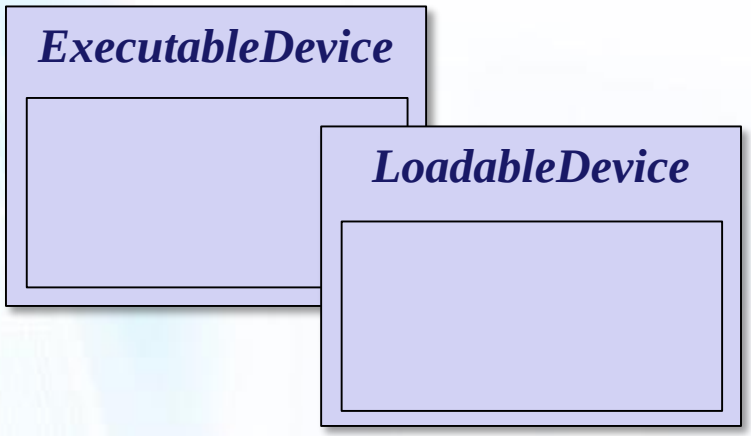
Computation Elements (cont.)

- **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

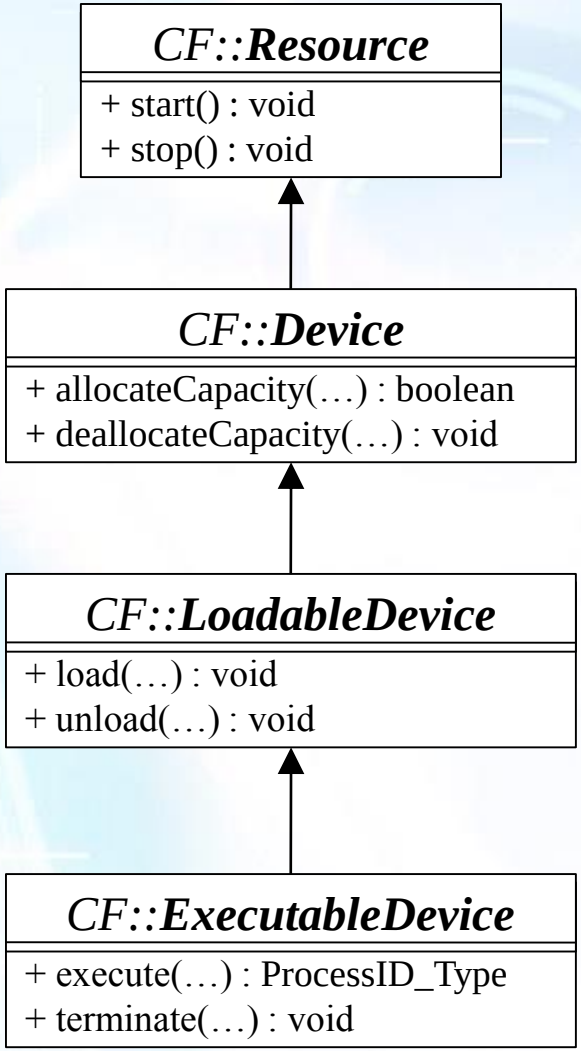
Mapping the SCA to a Software Defined Radio

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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