SDR Technology:
Present Realities vs Future Possibilities

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Coherent Logix™

Enabling Low Power Software Defined Systems

Photo Courtesy NASA

Coherent Logix Profile

Maker of low-power, high performance, C-programmable processors (HyperX™) and RF chipsets (*rf*X™) for the embedded systems market – enabling low-power, real-time software defined systems.

Wireless

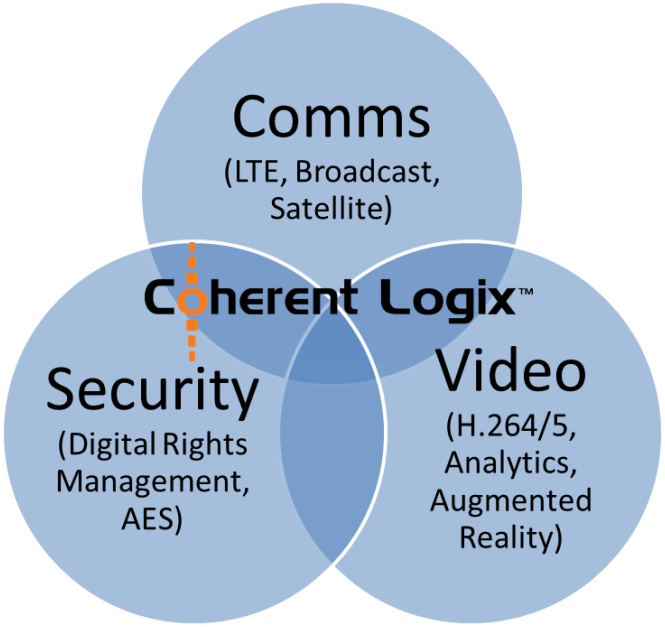
Image / Video

Mil / Aero

High-Rel

Coherent Logix™
Enabling Low Power Software Defined Systems™

The Coherent Logix Purpose



Coherent Logix is enabling the convergence of voice, video and image processing being securely transmitted wirelessly at very low power.

The world is changing too fast for traditional ASIC or even FPGA development cycles. Software Defined Systems are required since one can no longer anticipate every possible feature or requirement in advance, necessitating maximum flexibility at the lowest possible power consumption.

Introducing…the HYPERX™ processor

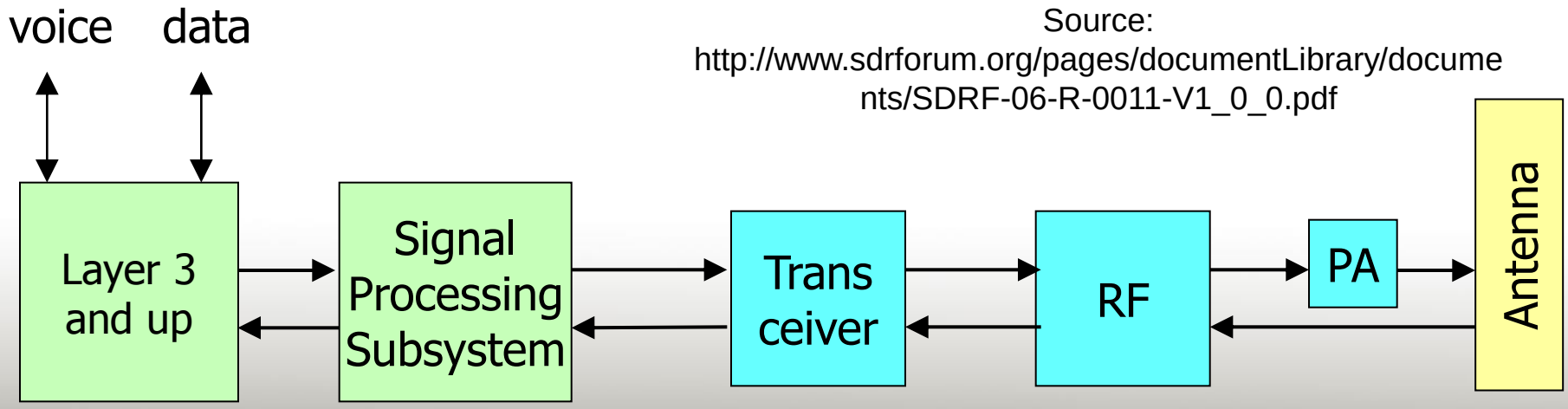
A very high performance, ultra-low power multicore (100) processor that:

- **has comparable power efficiency to an ASIC - better than DSPs and FPGAs, and much better than GPPs and GPUs,**
- **has the processing performance of an FPGA to do tasks that normally require hardware accelerators completely in software, such as LTE turbo decoding and H.264 CABAC,**
- **has the ease-of-use and C programmability of a GPP, resulting in faster time-to-market**
- **may be software upgraded after deployment to support new air interfaces, codecs, advanced algorithms, or niche variants (i.e., LTE MBMS for broadcast or 4:2:2 chroma format) which other processors are not capable of supporting today,**
- **can scale from both a hardware (i.e., I/O) and software perspective (i.e., code reuse),**
- **is low latency and 100% deterministic,**
- **is highly secure with advanced digital rights management and security features.**

What is ***Software Defined Radio*** (SDR)?

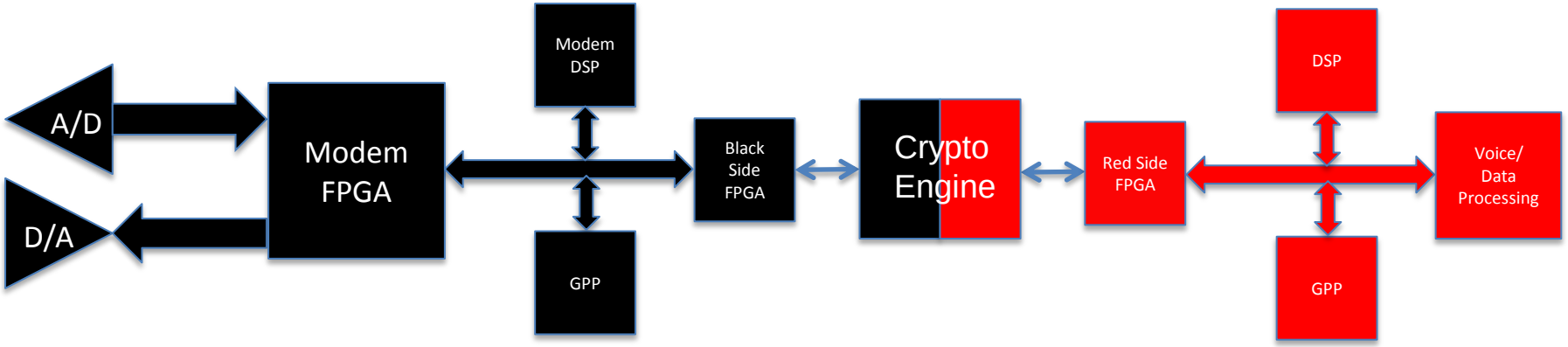
According to the latest definition agreed upon between the IEEE P1900.1 and the Wireless Innovation Forum, an SDR is:

Radio in which some or all of the Physical Layer Functions are software-defined



Source: http://www.sdrforum.org/pages/documentLibrary/documents/SDRF-06-R-0011-V1_0_0.pdf

Tactical Radios and Public Safety Radios are SDRs



Proven architecture, but:

- **Extremely lengthy software development cycle**
- **No heterogeneous tools available to program, test or debug at system level, so test and verification is extremely difficult and tedious**
- **Very limited code portability – even moving VHDL to a next generation FPGA family is non-trivial**

Cognitive Radios are SDRs
xG Technology: Coherent Logix HyperX-Based

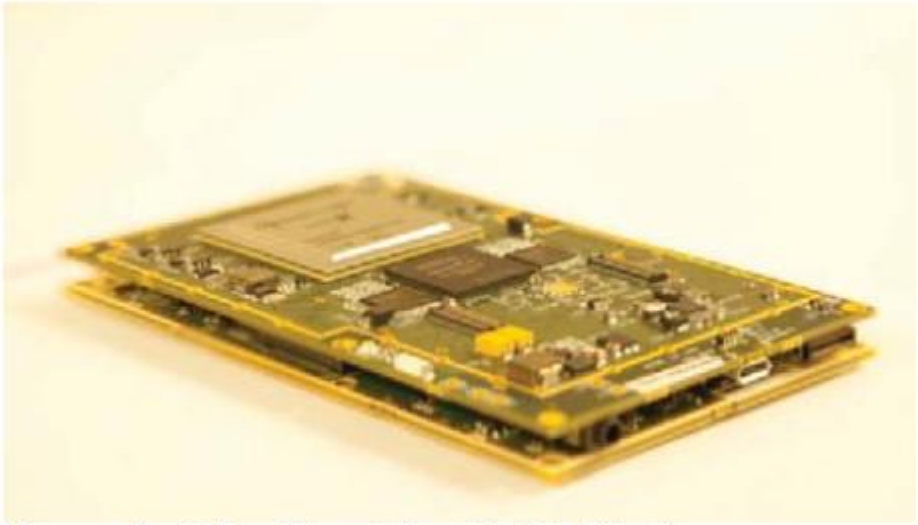
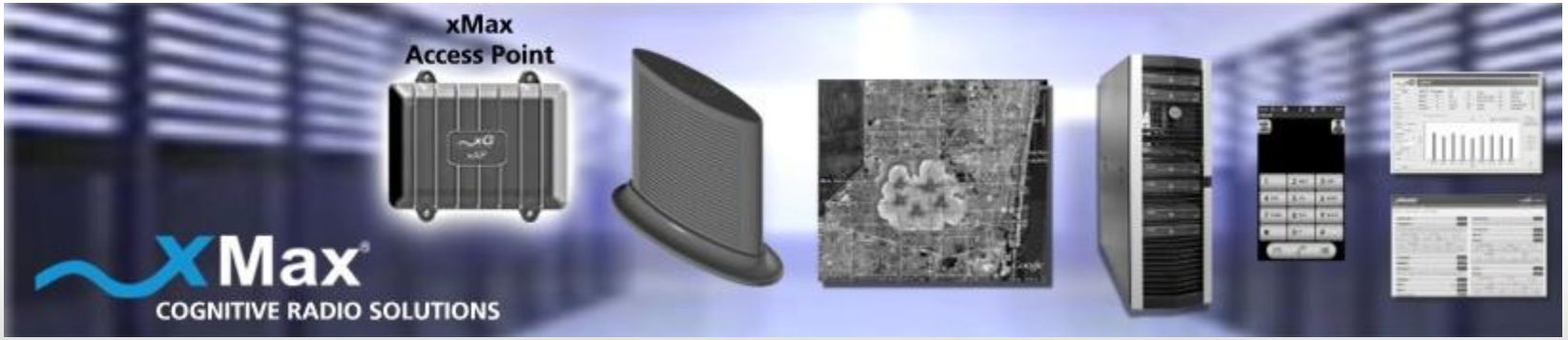


Figure 2. xMax Cognitive Radio Platform



Adaptrum: FPGA-Based

Carlson Wireless: FPGA-Based

This drove Carlson to a core design that is highly customizable. Running on a Xilinx Spartan-6 FPGA with an ARC CPU core and DSP blocks, Carlson is able to meet these requirements and provide TVWS service where needed, today. It's a relatively low cost implementation, able to hit

LTE Small Cells are SDRs
TI Small Cell Multi-Mode Architecture

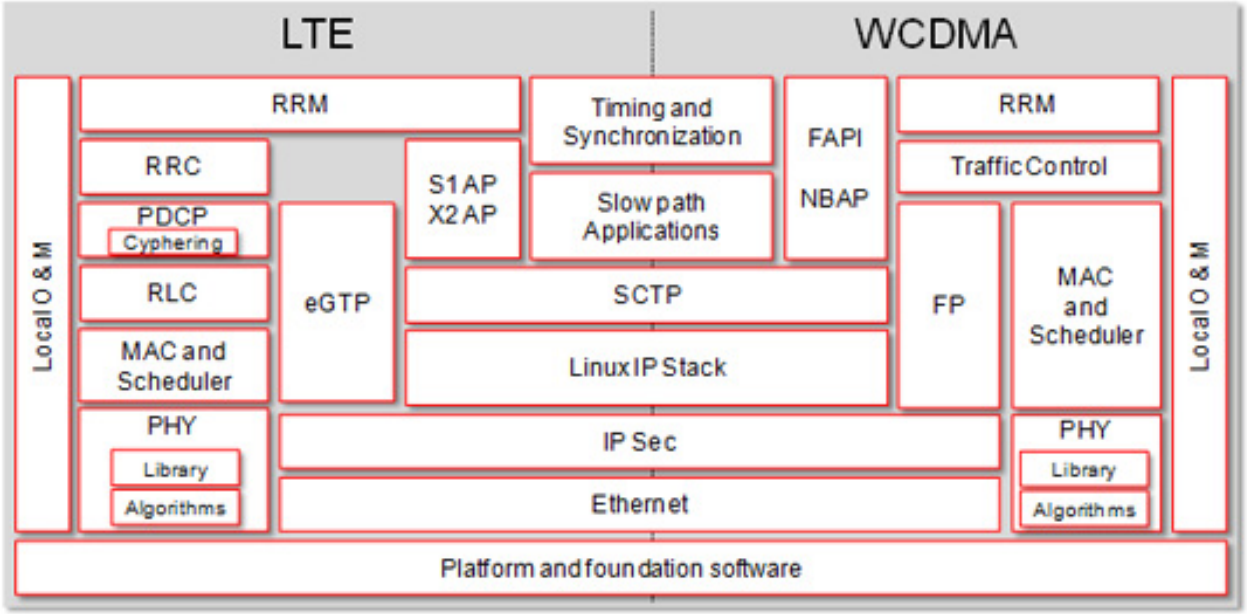
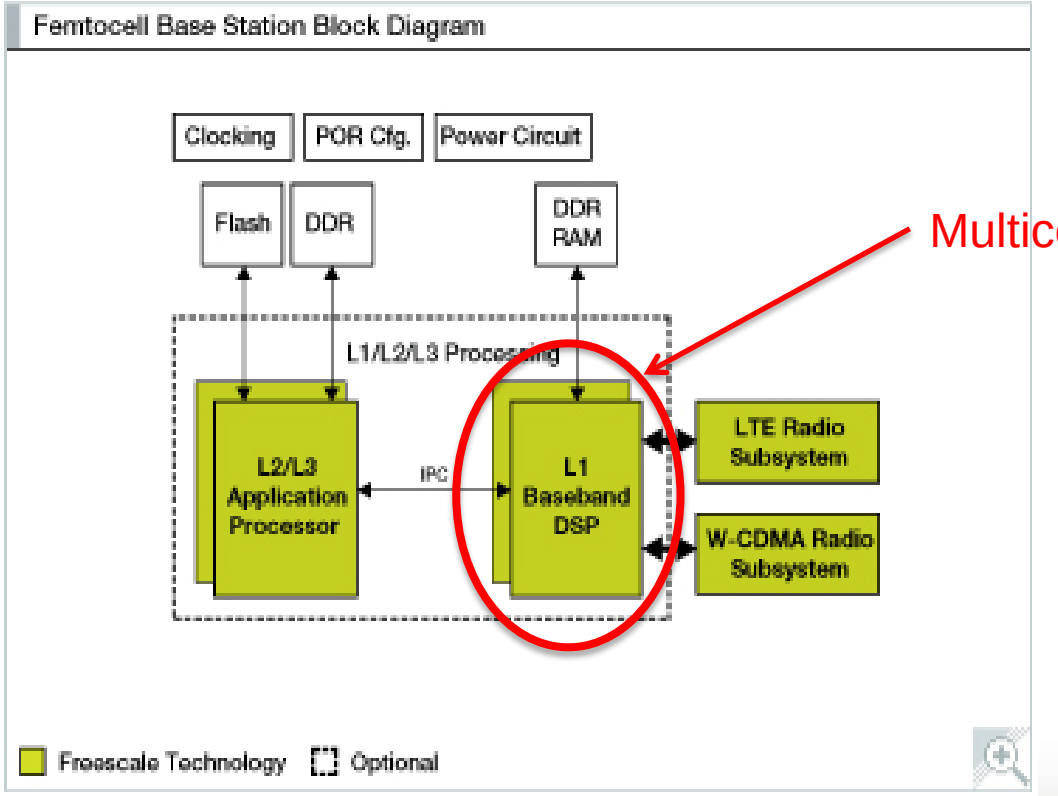


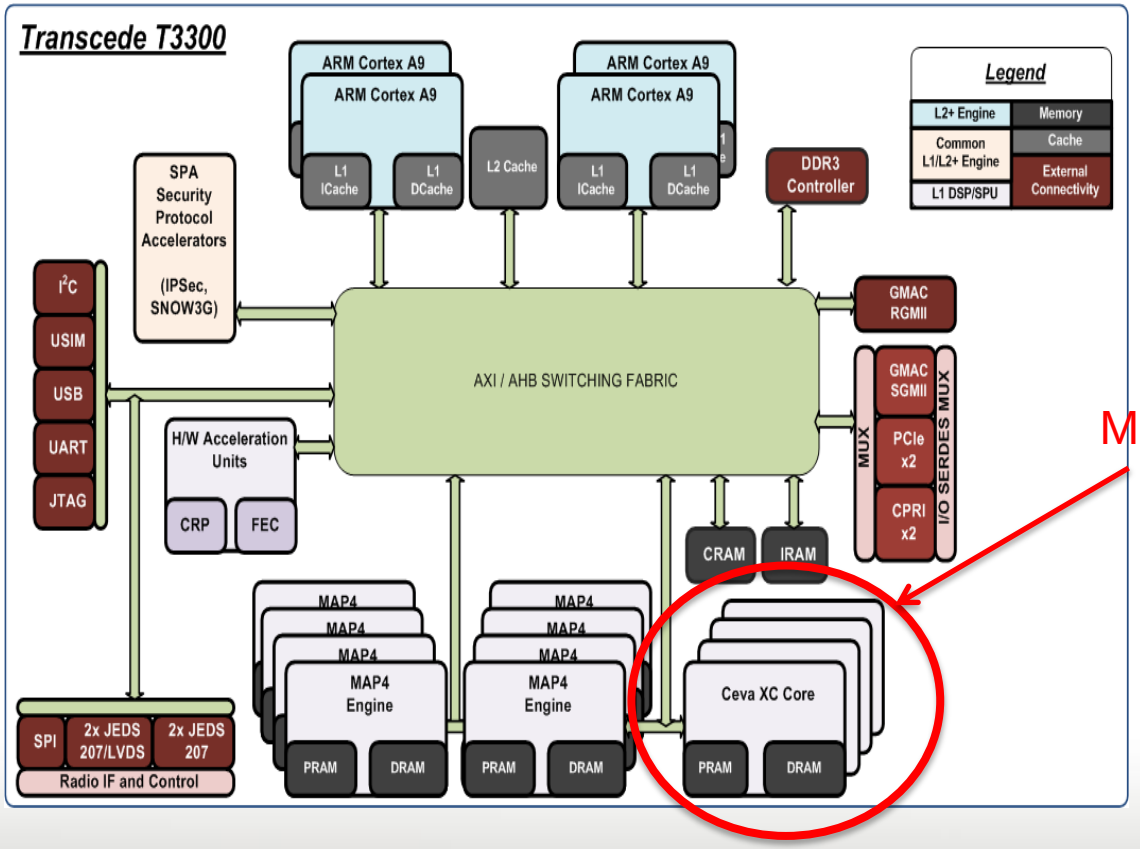
Figure 2: TI's small cell software architecture for LTE and WCDMA

Freescale Small Cell Chip



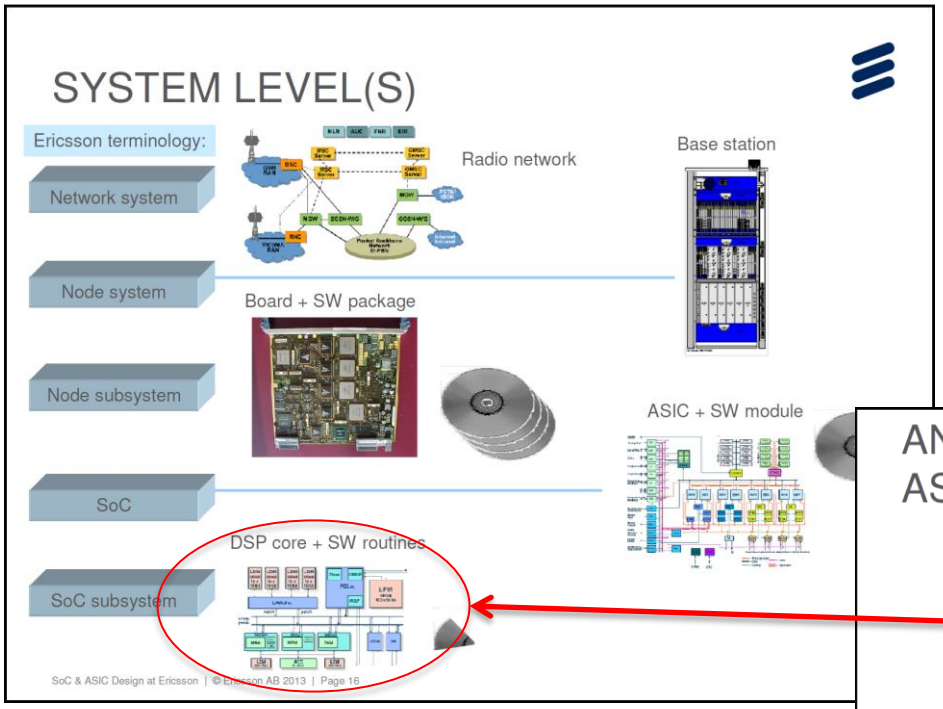
Multicore DSP Array

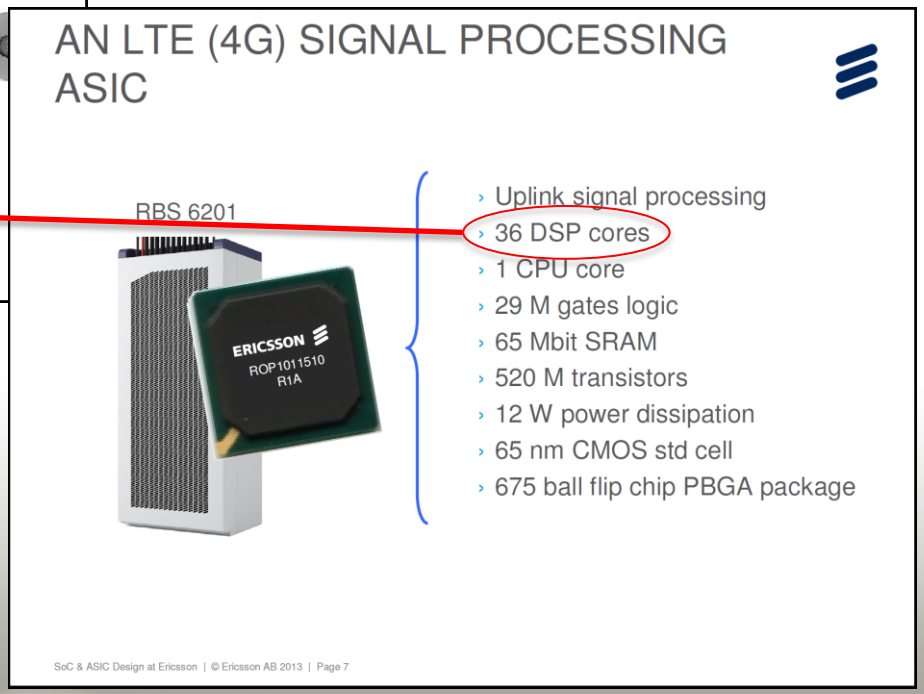
Intel/Mindspeed Small Cell Chip



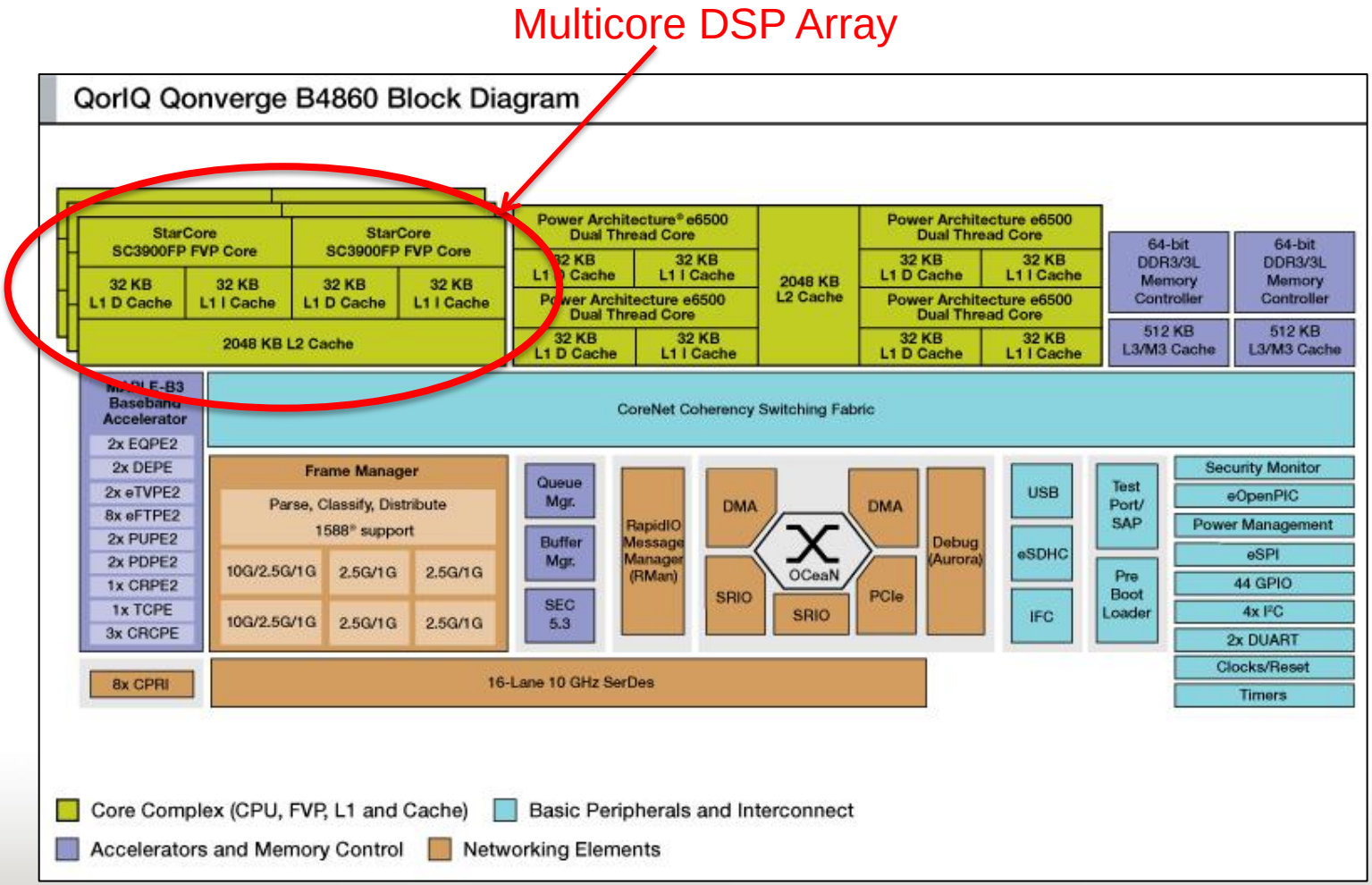
Multicore DSP Array

Macrocells are SDRs



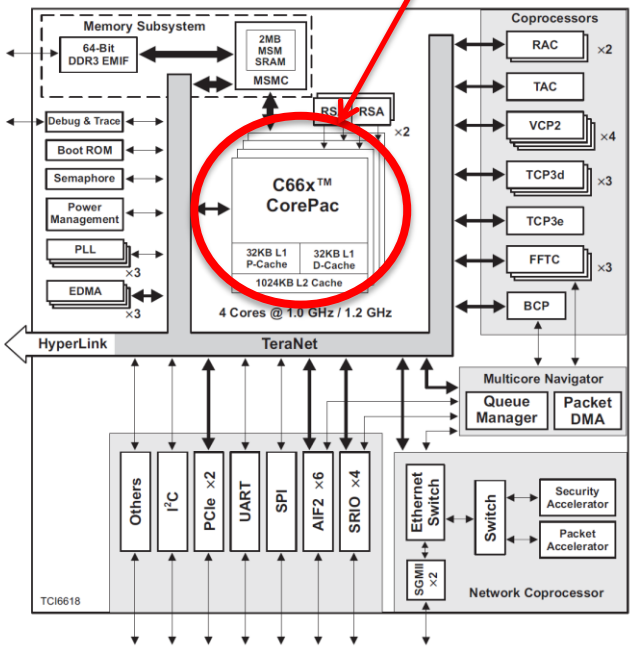


Freescale Large Cell Infrastructure Chip

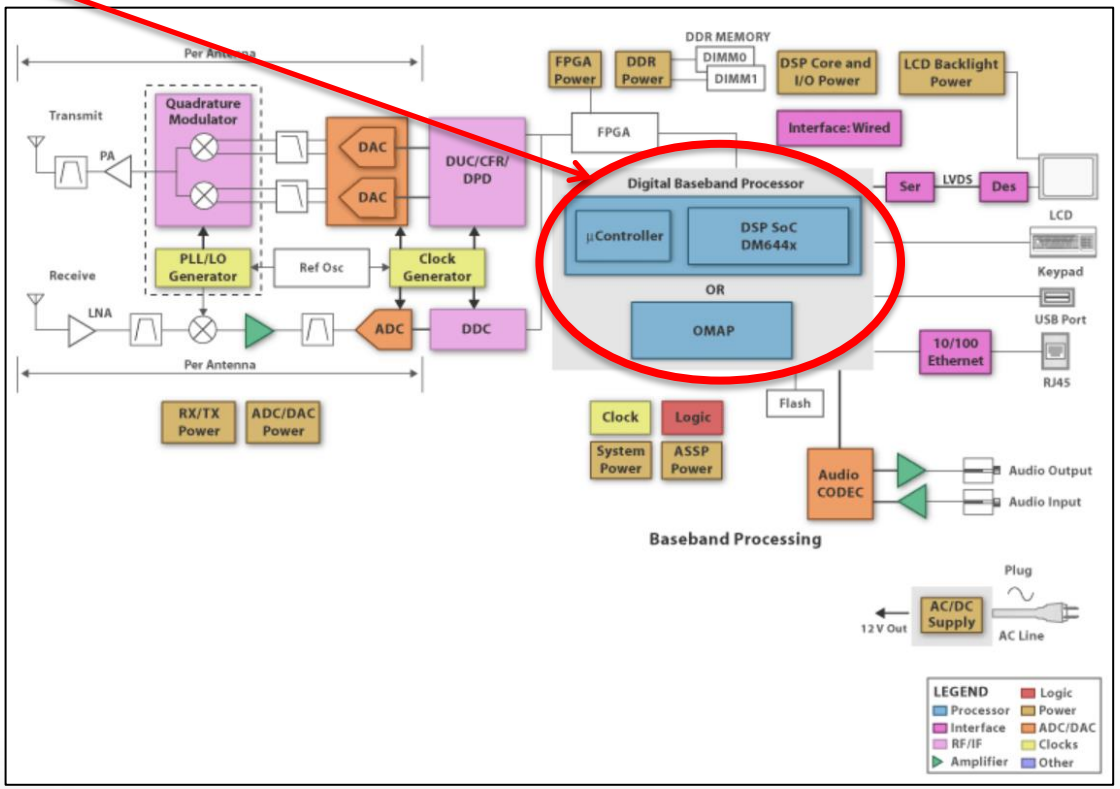


TI Large Cell Infrastructure Chip

Multicore DSP



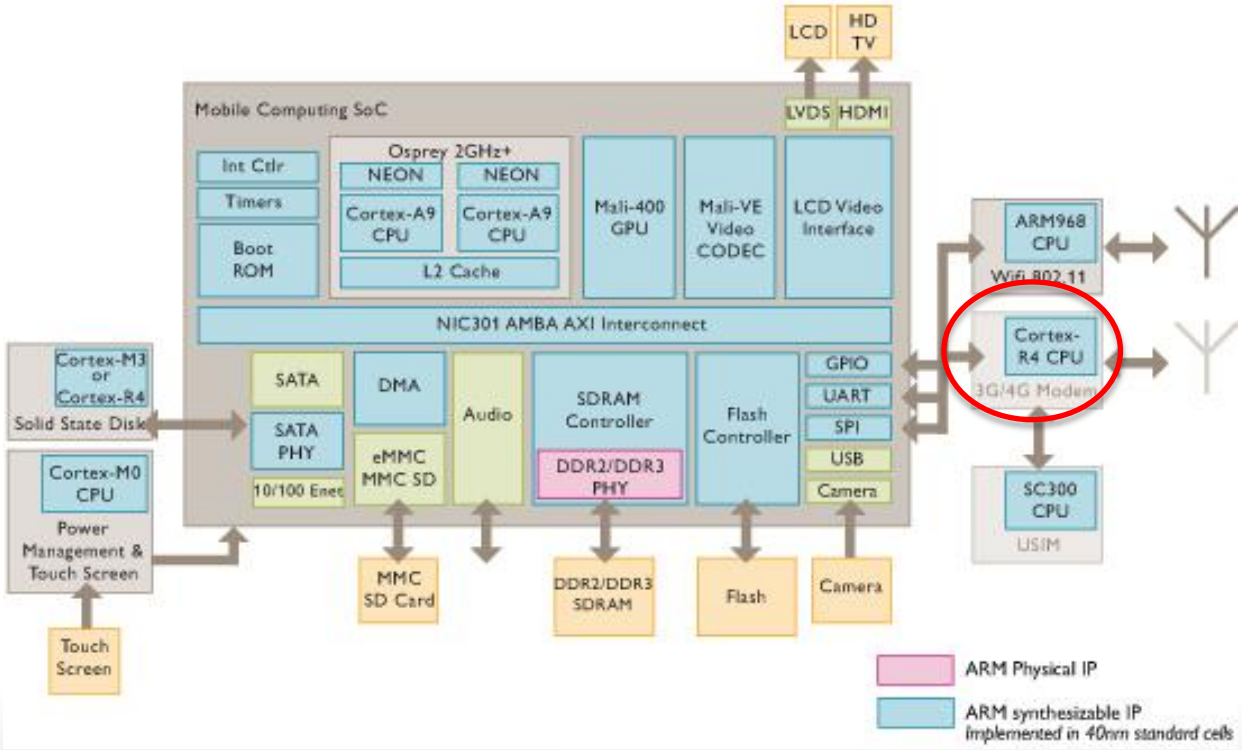
TI Keystone basestation chipset



TI SDR System Architecture

Source: http://www.ti.com/solution/software-defined-radio-sdr-diagram#

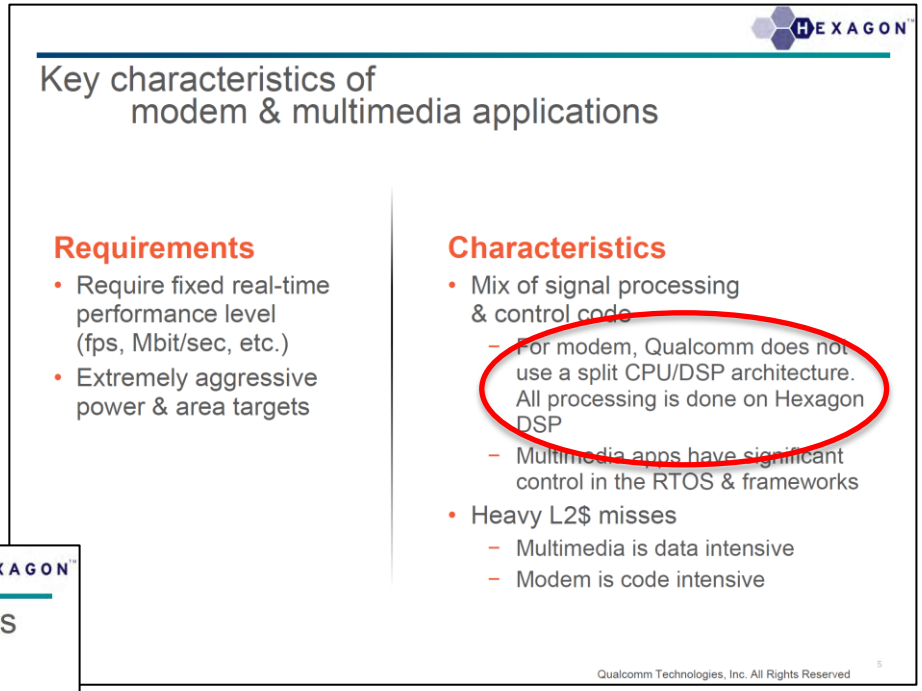
Even Handsets are SDRs
ARM Mobile Device Reference Design

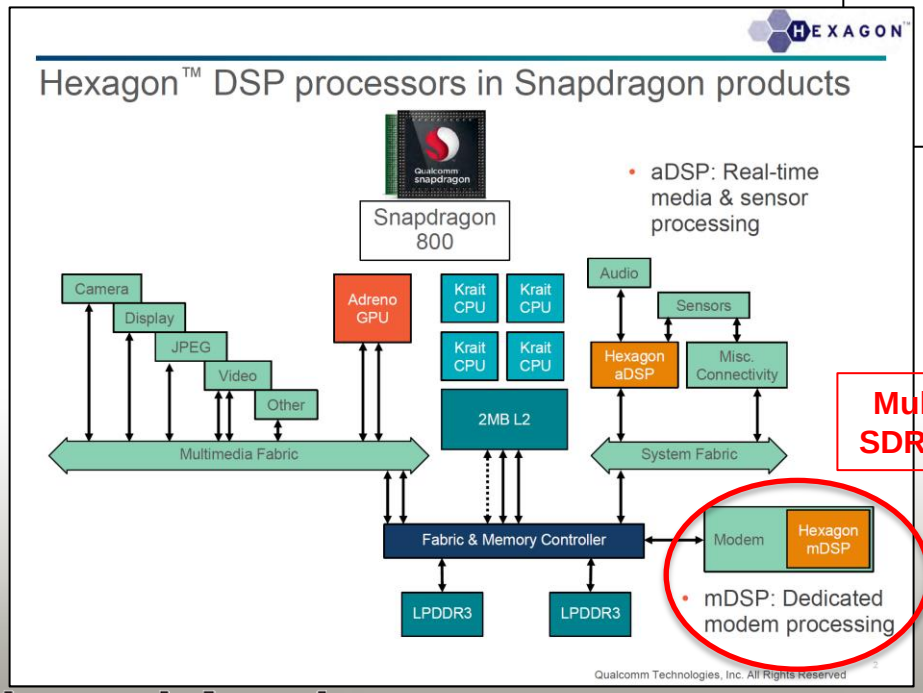


Source: Qualcomm

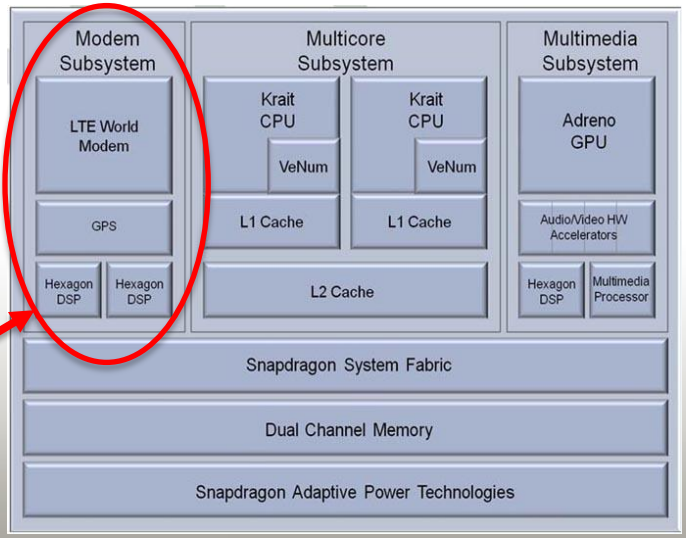
Qualcomm Snapdragon

- Snapdragon is the most successful handset chipset in the market today.
- Multiple Hexagon DSP cores are used to power the multimode SDR modem inside Snapdragon.
- Multiple generations (V1-V5) of Hexagon cores have been incorporated into Snapdragon for many years.
- It is in products from Apple, Samsung, Sony, LG, Nokia, Motorola, HTC, etc.



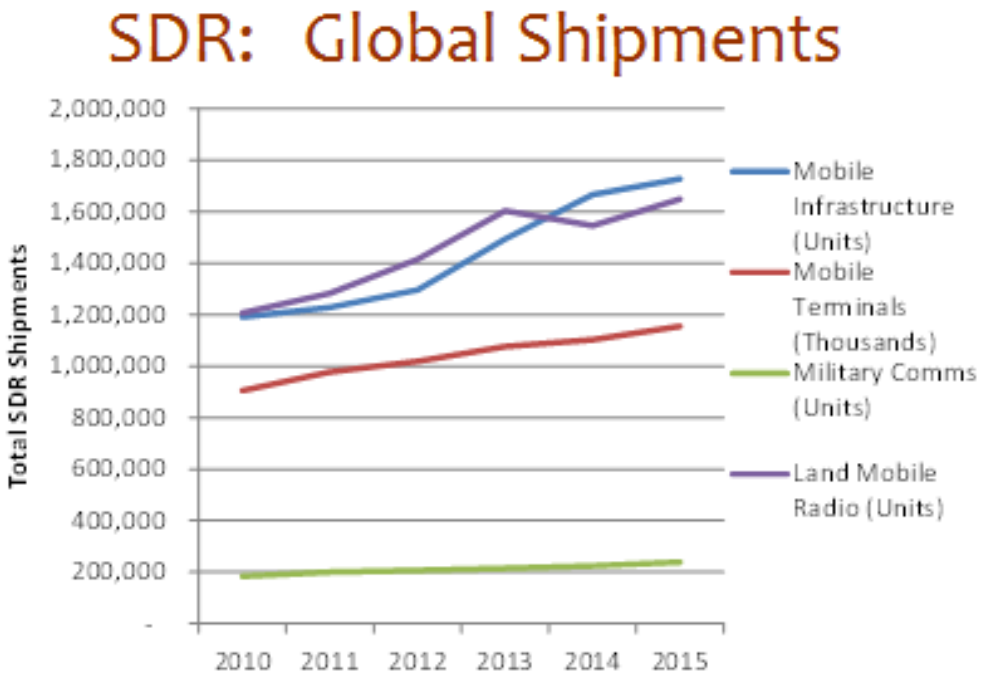


Multimode SDR Modem



Nvidia and Icera

4G: The Success of SDR



- Mobile Terminals represents the biggest segment by far
- SDR is taking analog market share in Public Safety and Private Mobile Radio (together known as Land Mobile Radio)
- Military Tactical SDR is growing more incrementally

MOBILE EXPERTS

Source: Wireless Innovation Forum SDR Market Size Study, 2011

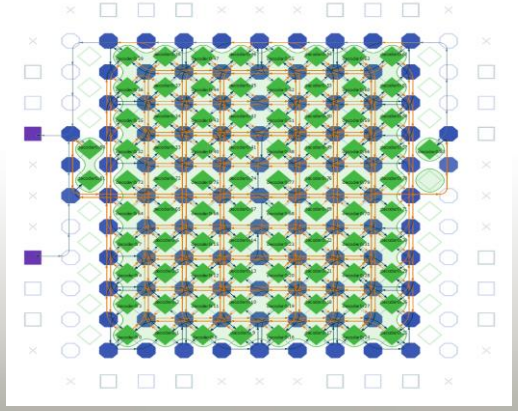
Most 4G eNodeBs and UEs are based on SDR technology!

Why Has SDR Been So Successful for 4G?

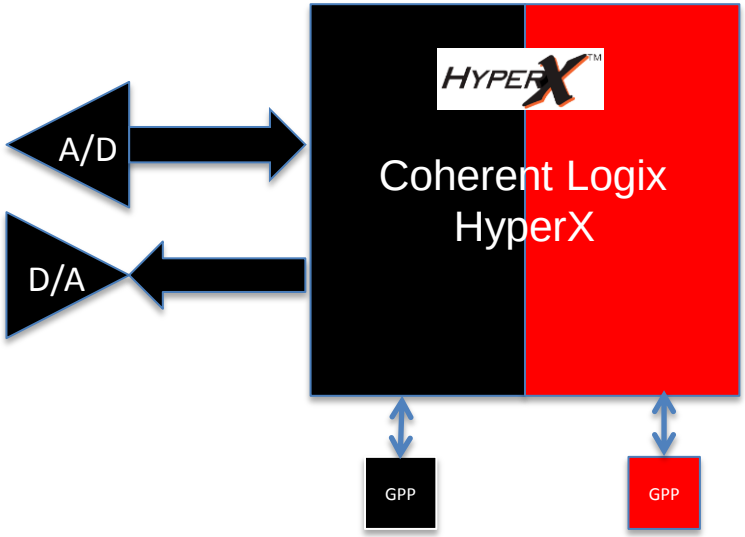
- **Requirement for multi-mode support**
- **Flexibility to add features or adapt to ever evolving air interface protocols even after deployment, and do so in a manner that is CAPEX and OPEX friendly**
- **Development cost savings of code preservation**
- **Time-to-market benefit from software code reuse**

Partial vs Fully Software Defined

- Some of the implementations previously shown are partially software defined since some key compute intensive functions are hardened (hardware accelerators), such as turbo decoding, MIMO and FFTs. This is done in order to achieve power and/or cost targets.
- The downside is a loss of flexibility, for example, an inability to support an air interface with a different FEC scheme, or unable to improve radio performance by updating MIMO or demod algorithms.
- At the 28nm node, it may finally be possible to achieve fully software defined implementations that can meet the power and cost targets.



Ideal Tactical Radio Modem Architecture



Single Chip Black Side/Red Side Modem:

- **Ideal SWAP (Size, Weight And Power) solution**
- **Major reduction in software development cycle**
  - "5x productivity improvement…as compared to FPGA…"
- **No VHDL required at all – all code in ANSI C**
- **Can program, test and debug at system level, reducing the time for test and validation**
- **Significant increase in code portability – all code in ANSI C**

Next Generation SDR Chipset for ATSC 3.0 Consumer Devices

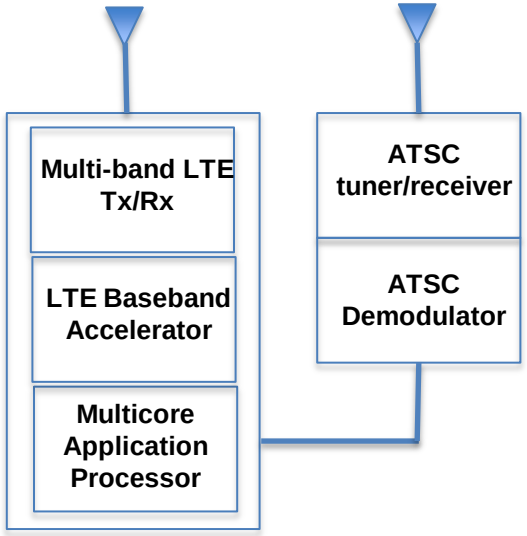
SINCLAIR BROADCAST GROUP

Today's radio chipset

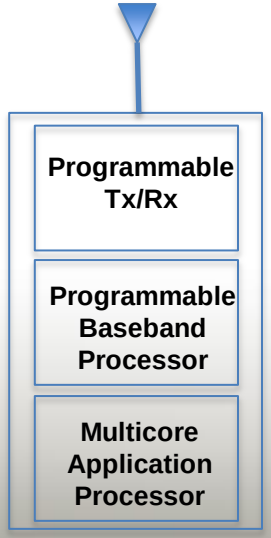
- External ATSC tuner/receiver
  - Added BOM cost, royalty, circuit board real estate, and power consumption
- LTE RF support is limited to a few bands (out of 40+ 3GPP LTE bands)
- Baseband processing is mostly hardwired circuitry with limited flexibility
- Broadcast and broadband are separate functions

New generation radio chipset

- Programmable baseband processor to support all waveforms
  - For example, ATSC and LTE at the same time
  - Single chip solution, no separate ATSC chipset
- Programmable RF to support all bands from VHF/UHF to a min. of 5GHz
- Cost/size/power neutral when compared to today's chipset
  - No compromise while supporting more functionalities
- SW stack to support broadcast/broadband convergence and off-load



Current Chipset



New Generation Chipset

Coherent Logix™
Enabling Low Power Software Defined Systems™

Next Generation Handset by Top-5 OEM

Working with one of the world's largest handset manufacturers to define and design a multi-purpose chip and software-reprogrammable system, for next generation handset.

The chip must support different types of modems, as well as camera, computational imaging, navigation, augmented reality, sensor processing, and other future signal-processing requirements.

Since it is difficult to define the ASIC requirements 18 to 24 months ahead, a Software-defined flexible chip is required.

This will be a next generation HyperX processor at 20/28nm.

HyperX Processor Figures of Merit

	hx3100	hx4XXX	2016 (hx4XXX)	2016 (hx5XXX)
Process technology	65nm	28 nm	16 nm	16 nm
GFLOPS/W (Based on FIR)	12	113	191	470
GOPS/W (based on FIR)	46	905	1531	3764
GOPS/W (based on Turbo decoder and ME)	77	1358	2296	5647
Power consumption (mW; LTE UE baseband)	3300	250	168	86
Power consumption (mW; H.264/AVC HP 1080p30 L4 : Prof. Qual.)	4500	274	184	94

Conclusions

- **SDR is the de facto standard for almost all radios today**
- **Key factors that drove adoption are flexibility, development cost savings and faster time-to-market**
- **But some SDRs today are only partially software-defined**
- **The future trend favors completely software-defined implementations**
  - No hardware accelerators, no RTL, no VHDL!
- **Multi-core processors, such as the HyperX processor, are an enabling technology for complete SDR implementations**

Thank you!

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Photo Courtesy NASA