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Minds in Motion

Using Serial RapidIO® Switches in Wireless Node B Baseband and WiMAX Architectures using Texas Instruments DSPs

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Outline

1) Evolving network requirements for data services
2) The migration of MAC services
3) Switched baseband architecture to support high-speed data services
4) Architectural examples with C6482 and TCI6487
5) High-level processing partitioning
6) Examples of MAC-PHY interaction for HSDPA in a switched baseband architecture
7) Summary of architectural trends

Pressure from Wireless Data

- HSDPA and HSUPA in UMTS Release 5 to provide wireless packet data to subscribers
- WiMax 802.16e deployment also seeking to provide wireless broadband
- In both cases, the wireless data demands are redefining baseband architectures

Baseband Module Complexity

	DO Rel A	HSDPA	WiMax(802.16(e))
DL peak data rate Bandwidth	3.07 Mbps 1.25 MHz	14.4 Mbps 5 MHz	70mbps 20 MHz
UL peak data rate	1.8 Mbps	2 Mbps	20 Mbps
IP termination	RNC/PDSN	RNC/PDSN	BTS
Bandwidth efficiency features	- CDMA + Low latency - IP at RNC	- CDMA + PHY HARQ - IP at RNC	+ OFDM - MAC HARQ + IP at BTS
Standars compatibility	Yes	Yes	Yes
Deployment	2005	2005	2005
Duplexing BB complexity	FDD ~1.2 million gates	FDD ~1 million gates	TDD / FDD ~2.5 million gates

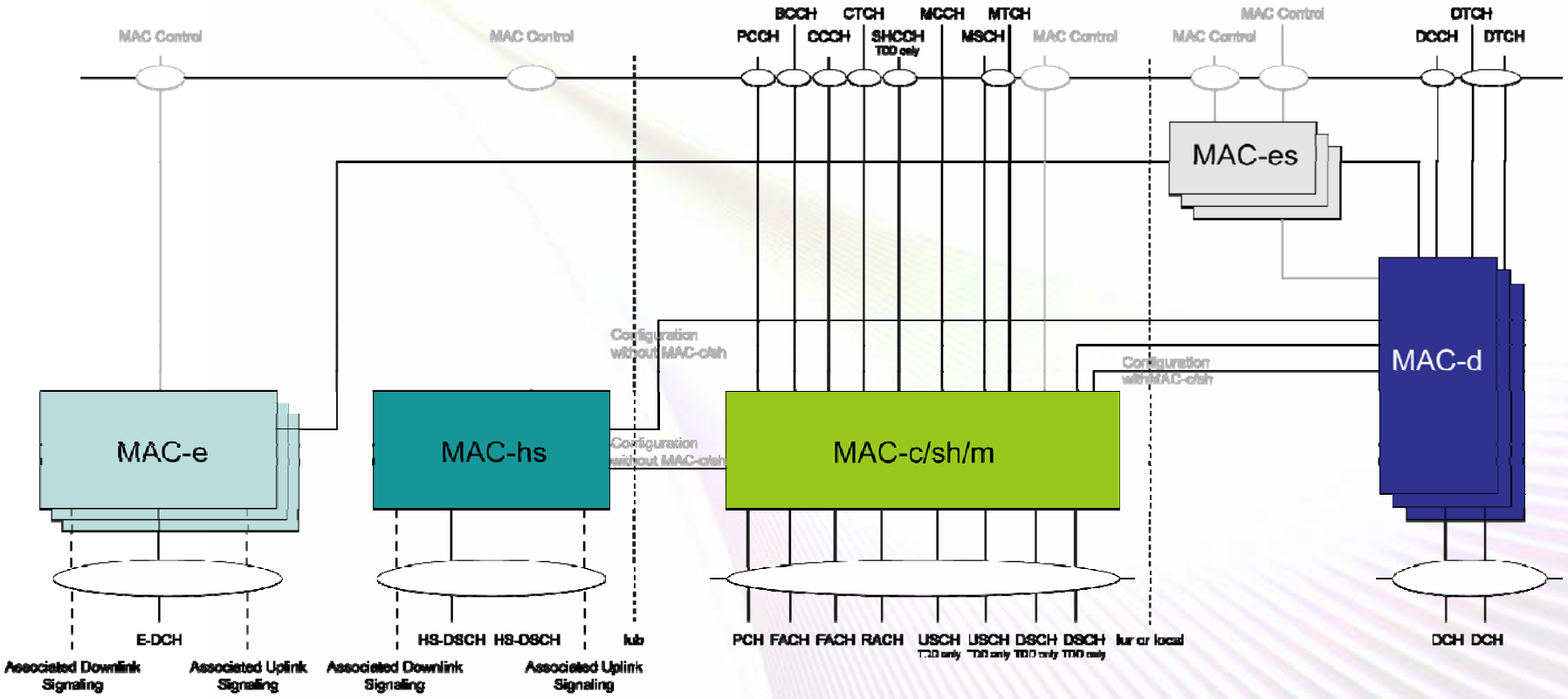
MAC Characteristics

	3G HSPDA	3G EV-DO	WiMax(802.16(e))
Bandwidth, MHz	5	1.25	<20
Data rates, Mbit/s	14.4	2.4	75
bit/Hz	2.9	1.92	3.75
Multiple access	TDMA, CDMA	CDMA	OFDMA
Duplexing	FDD	FDD	TDD
Mobility	Full	Full	Nomadic/Full
Coverage	Large	Large	Mid

MAC Layer: HSDPA

- In UMTS R99, the Radio Network Controller (RNC) essentially took care of the whole MAC-layer protocol.
- However, with a 2ms TTI (transmission time interval) vs. the >10ms TTI in R99, user plane MAC control needed to move to the Node B.
- RLC remains in RNC – handling fragmentation, packing, ciphering, scheduling and ARQ.
- MAC-D remains in RNC – mapping logical channel to appropriate transport format.
- MAC-HS goes to Node-B – handling H-ARQ support, fast scheduling and AMC control.

UMTS R6 MAC Architecture



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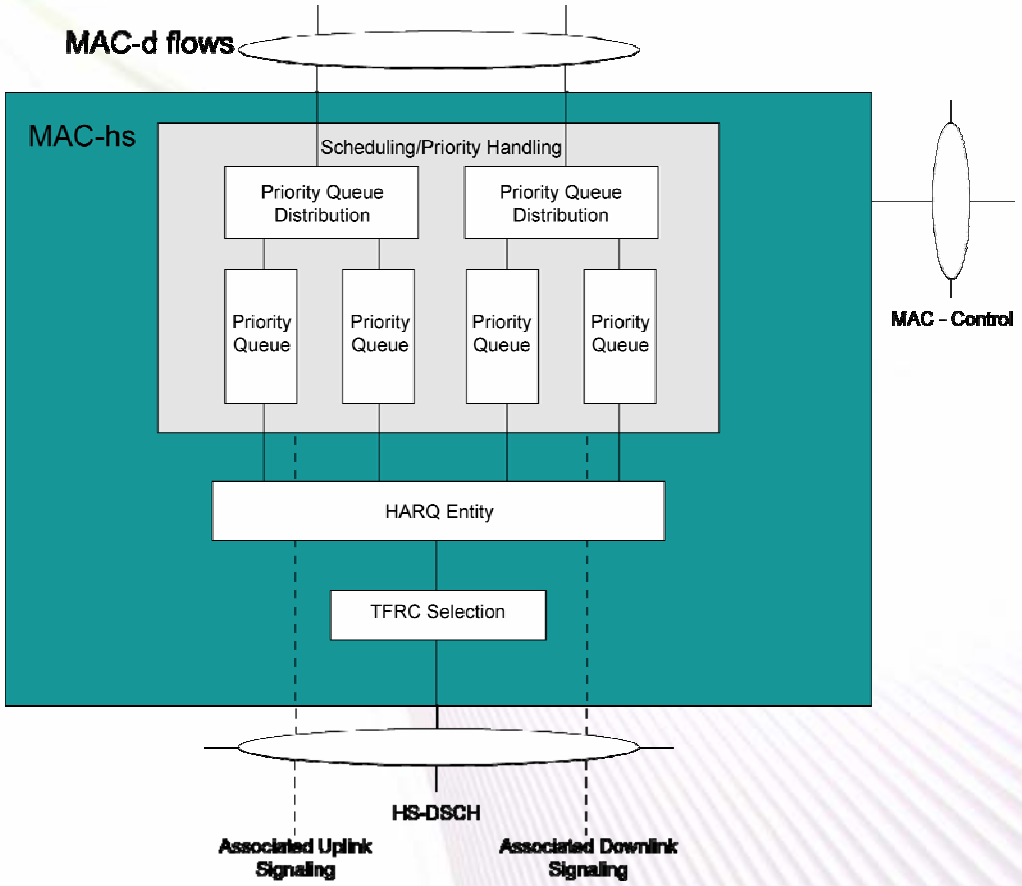
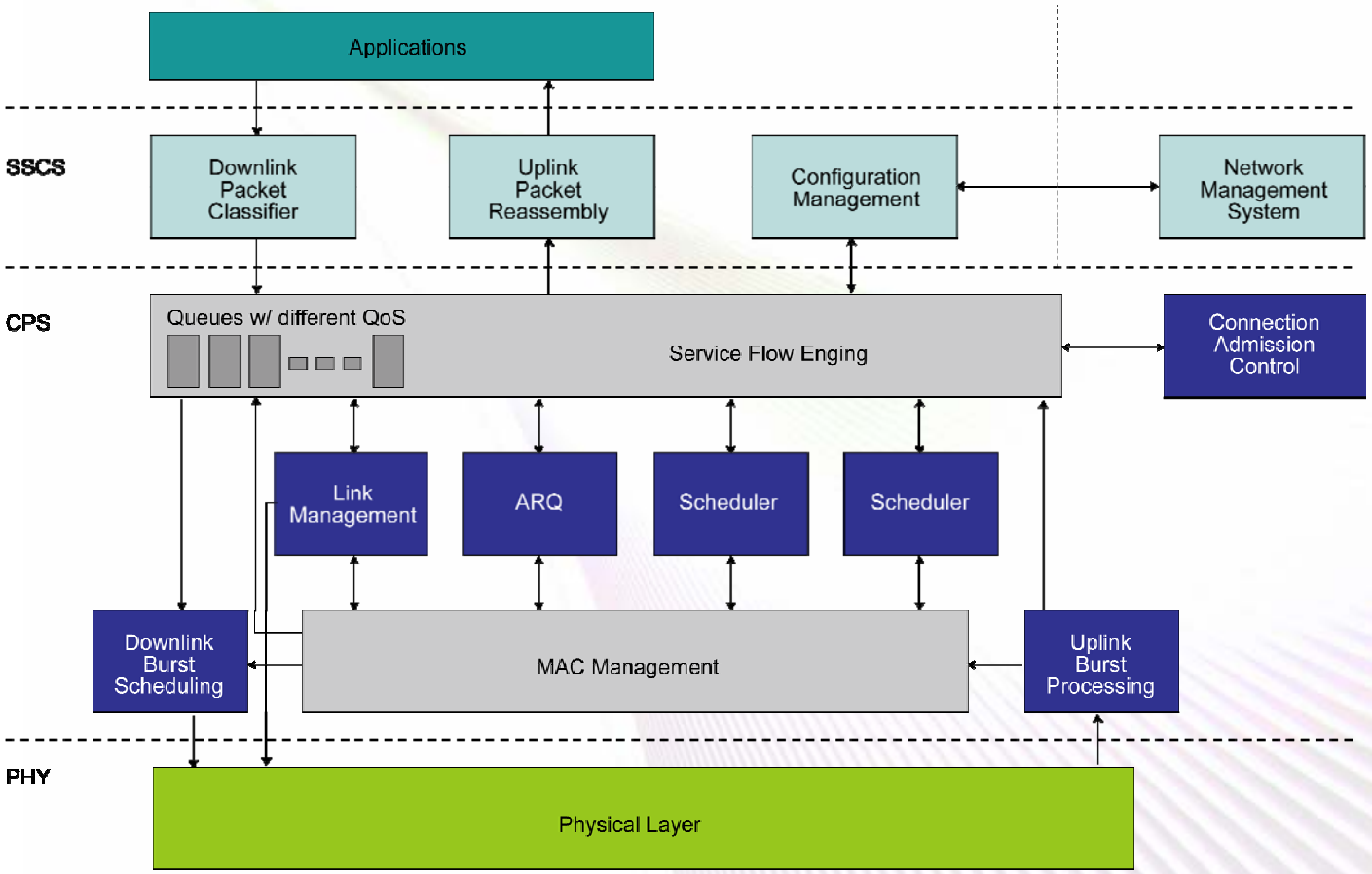
MAC-hs in Node B: HSDPA



MAC Layer: WiMax 802.16e

- The MAC layer consists of three sub-layers:
  - The service-specific convergence sub-layer (SSCS) provides an interface to the upper layer entities through a CS service access point (SAP).
  - The MAC common part sub-layer (CPS) provides the core MAC functions, including uplink scheduling, bandwidth request and grant, connection control, and automatic repeat request (ARQ).
  - The privacy sub-layer (PS) provides authentication and data encryption functions.

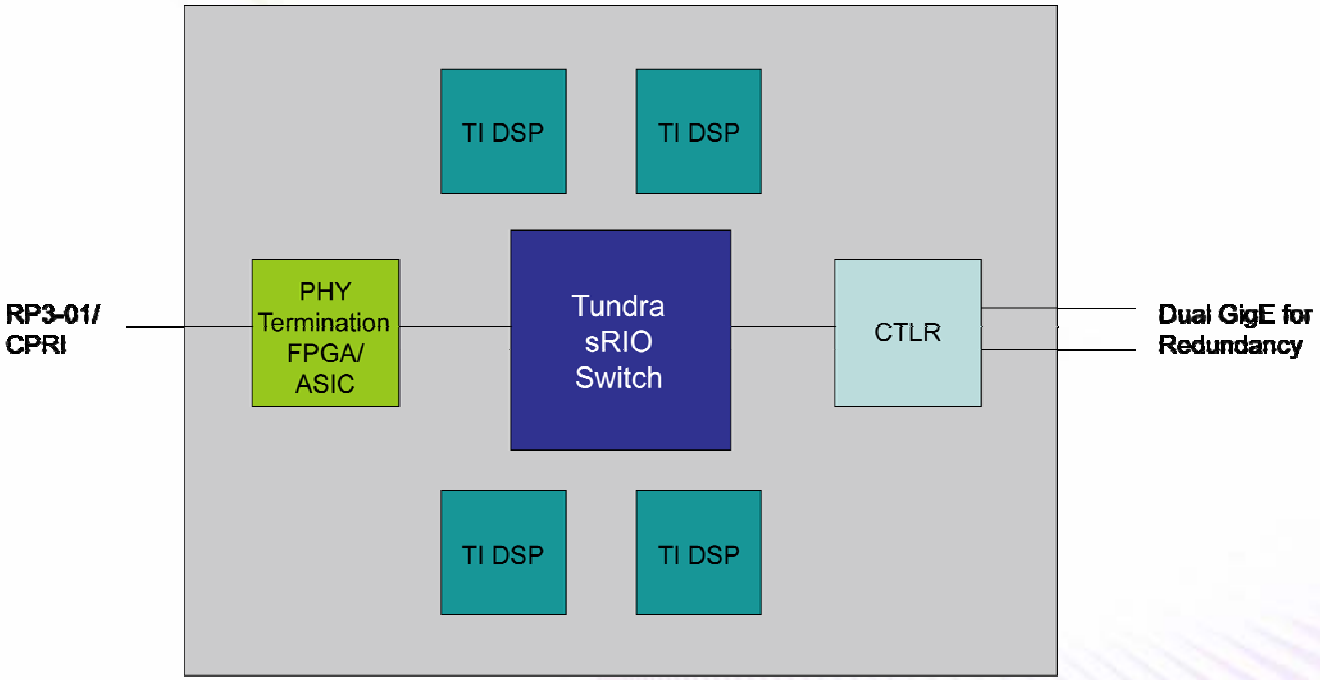
WiMax 802.16e MAC Architecture



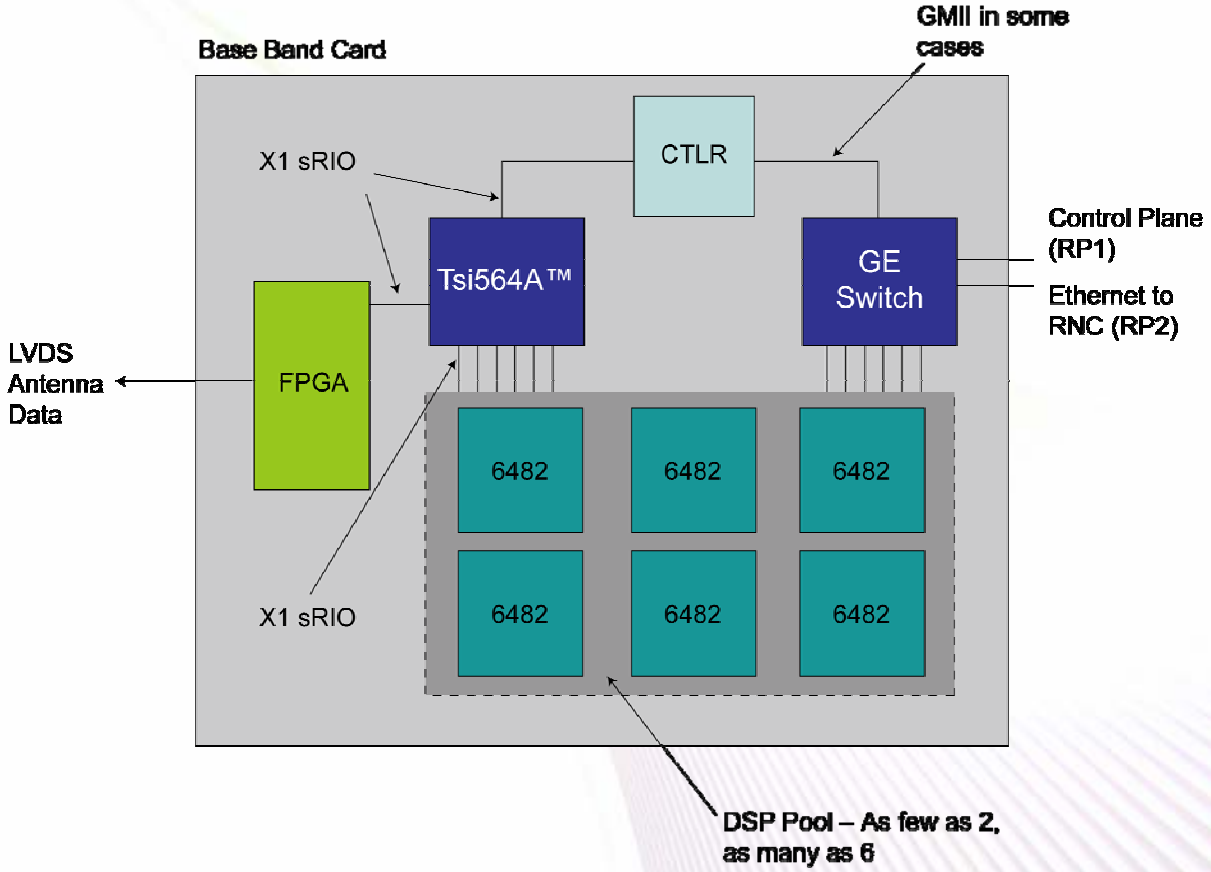
Switched Baseband Architecture

- MAC operation is dependent on low latency interaction for AMC (adaptive modulation and coding) control.
- PHY operation is increasingly migrating to distributed processing with DSPs (e.g., TCI6487 and C6482).
- A Serial RapidIO-based switched architecture provides a low-latency high-bandwidth approach.

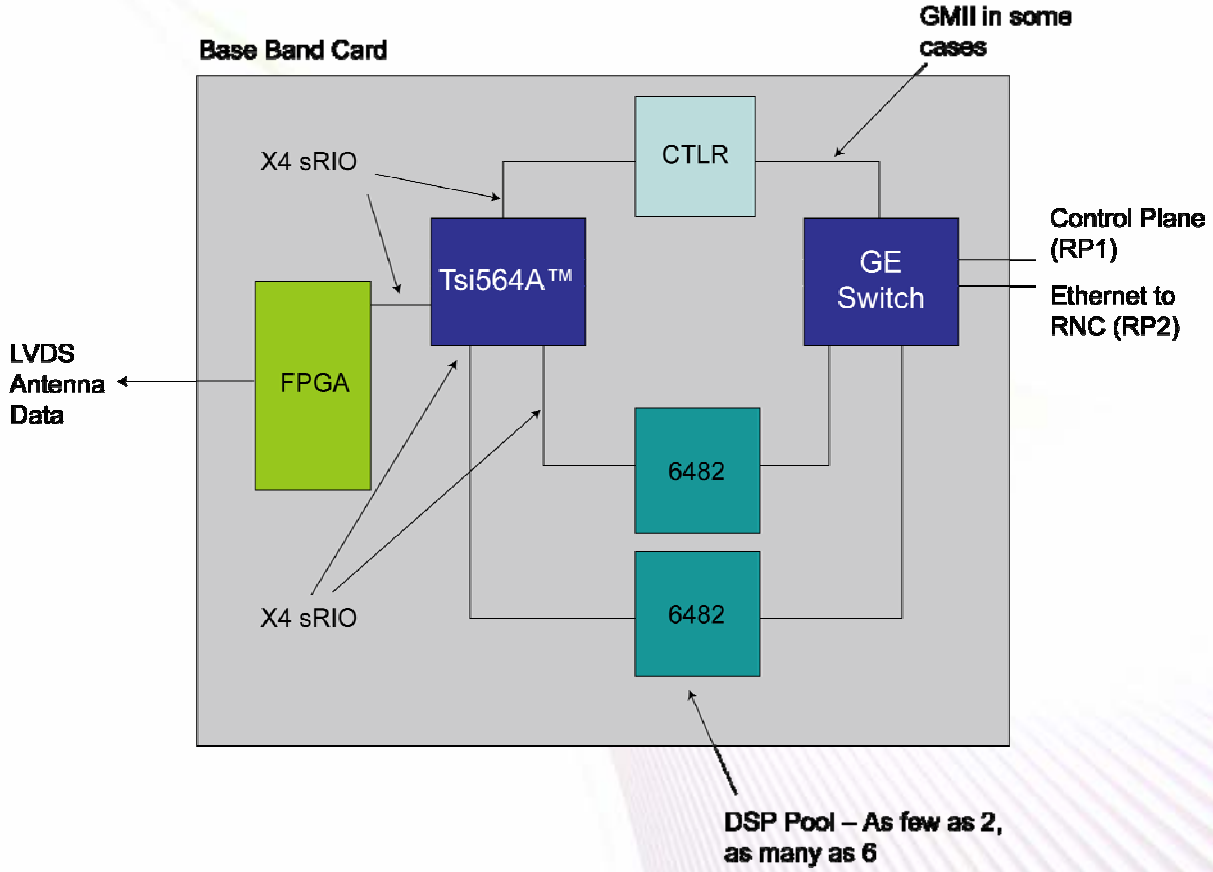
Generic Example



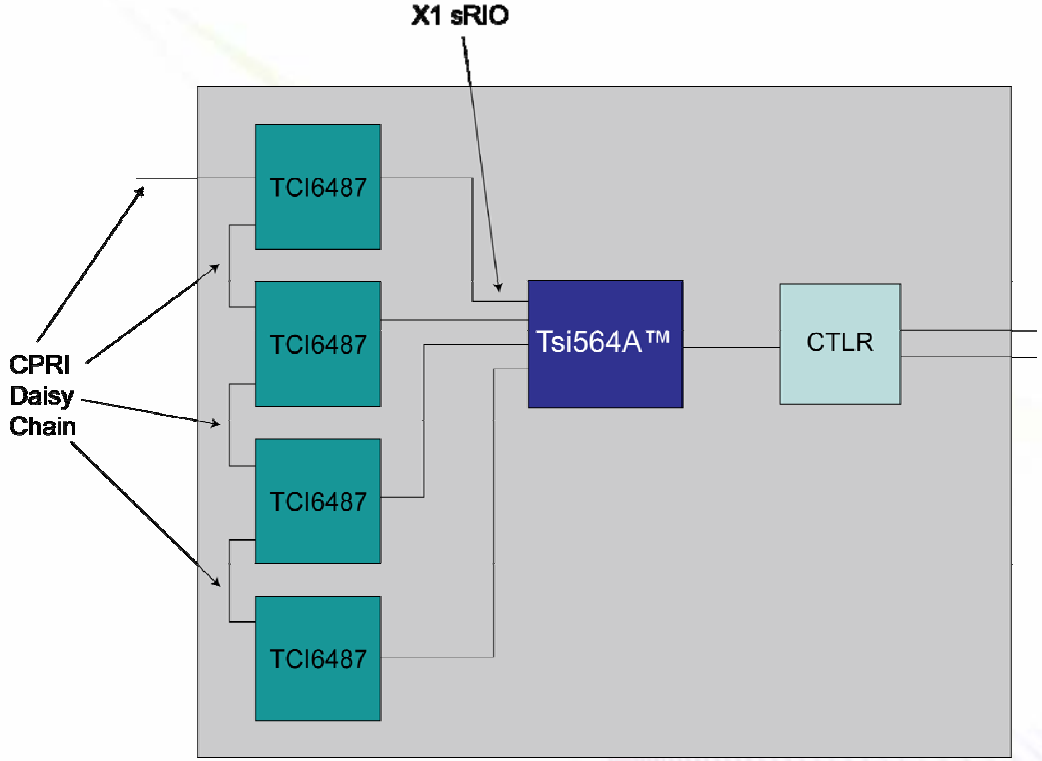
WCDMA HSDPA with C6492



WiMax 802.16e with C6482



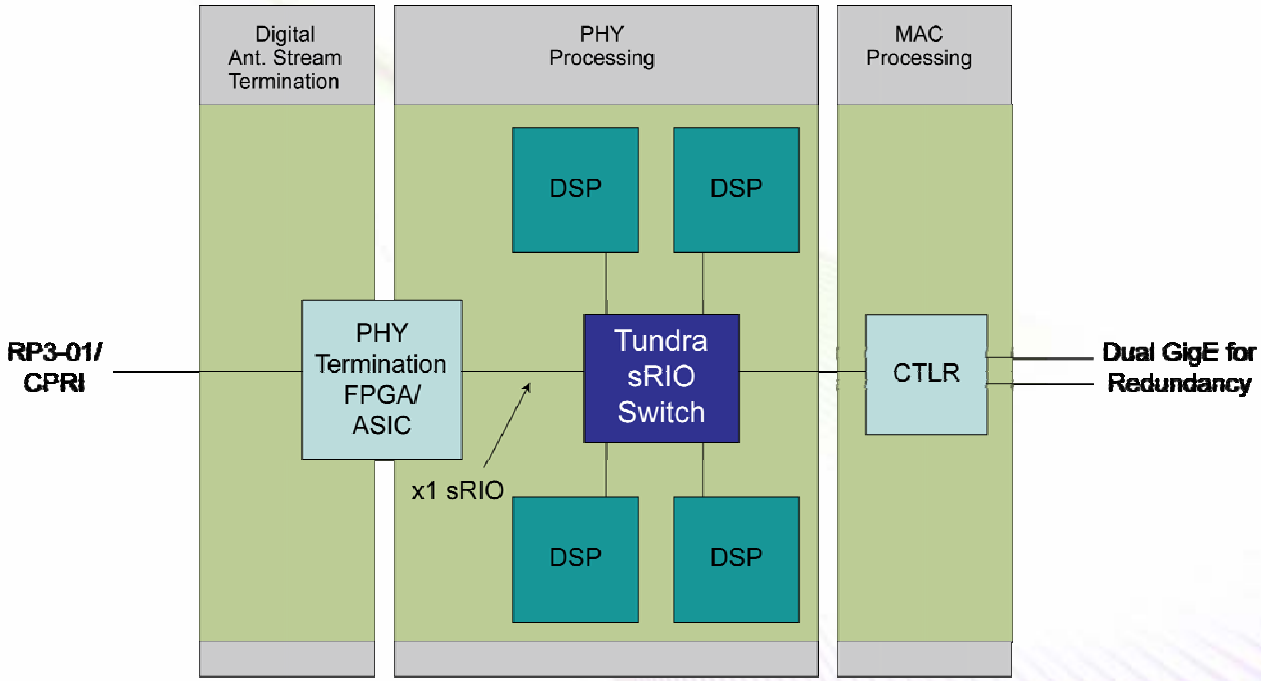
WCDMA HSDPA with C6487



Baseband Architectural Themes

1) Ethernet switch is common to aggregate U-plane and C/M-plane data from DSPs.
2) Radio Network L2/L3 functions being integrated in the Baseband Module, requiring more processing partitioning.
3) Serial RapidIO switch is common since Serial RapidIO is ideal for connecting peer processors performing different tasks.
4) Antenna interconnect is standardizing on CPRI and RP3. (CPRI is more common based on designs we have seen.)
5) Standard DSPs are still not expected to completely manage Radio Network PHY processing. FPGAs and ASICs expected to manage a significant portion of this processing.
6) There's a focus on programmability, flexibility and scalability in baseband design.
7) PHY layer pre-processing in the switch is actually untenable. User plane IQ data stream is always carried on antenna interface (not Serial RapidIO) and always enters at DSP or FPGA for termination. No architectural option for pre-processing in virtually all observed architectures.

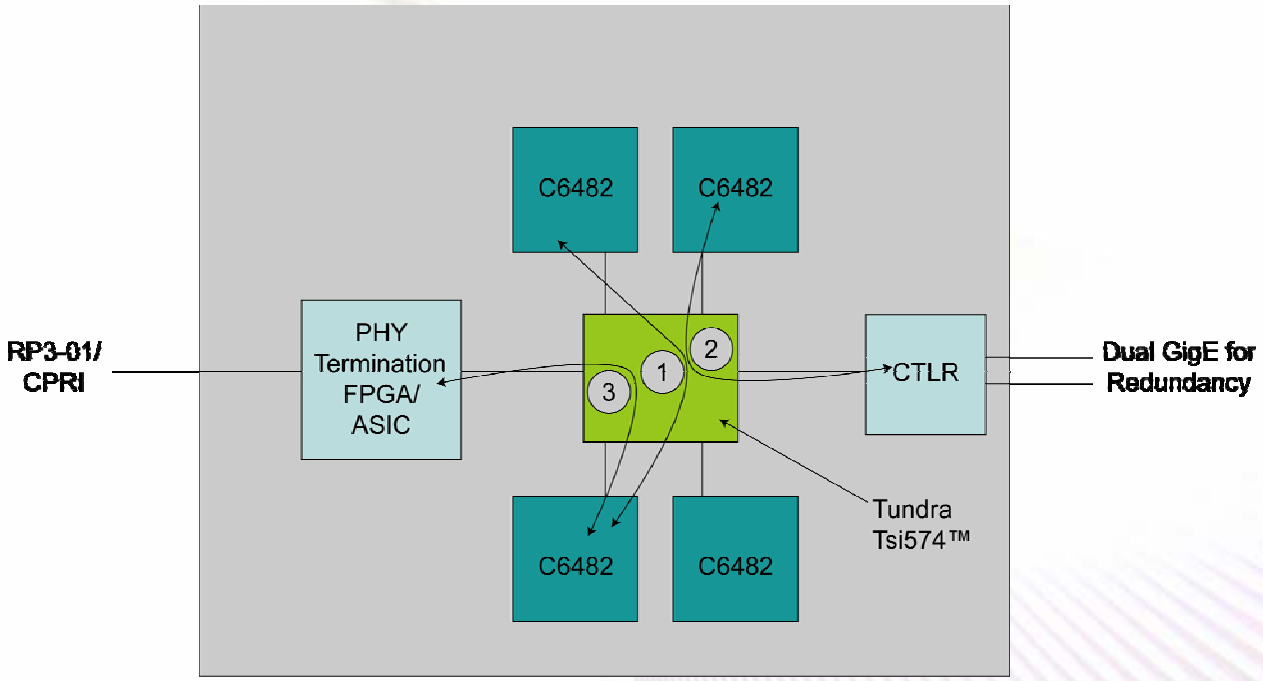
MAC/PHY Partitioning



Processing Description

- **Hybrid ARQ (H-ARQ):** Used in UMTS Release 5, but is optional in 802.16e.
- **Adaptive Modulation and Coding (AMC):** Used in both UMTS Release 5 and 802.16 to vary the transmission mode and coding to match changes in radio channel conditions.

Processing Interaction with Tundra Switch



Processing Loops

1) Codec Load Balancing
   - DSPs load balancing the codec portion of the PHY layer. For example, symbols from chip-rate processing are shared out among subset of DSPs for turbo-decoding.

2) MAC/PHY Interaction
   - MAC-hs controlling adaptive modulation based on channel quality.

- 3) Modem/Codec Interaction
  - Multi-user detection techniques in UMTS require feedback loops between channel estimations and rake receivers.
  - Fast Power Control loop requires interaction between pilot bit estimation and signal noise ratio on uplink with TPC information on the downlink.

Summary

- Wireless data services are driving higher bandwidth and tighter latency constraints in the Radio Access Network.
- This is redefining the complexity of the baseband module in both UMTS and WiMax 802.16e infrastructures.
- A Serial RapidIO-based switched architecture enables cost-effective, high-bandwidth and low-latency architectures on the baseband card.
- Tundra Serial RapidIO switches are currently deploying in a number of new baseband architectures for both WiMax and UMTS.