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ModemX

Heterogeneous Multi-Core Architecture for SDR Applications

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Agenda

- Introduction
- ModemX Architecture
- Application Examples
- Summary

Introduction

- ASOCS Introduction
  - Developer of many-core embedded processors enabling seamless connectivity over diverse wireless networks
  - Pioneer of ModemX technology
  - Expertise in algorithms, DSP, software and firmware for wireless, cellular and broadcast
  - Founded in 2003, Head quarters in Afek Park, Israel
  - Investors

- ModemX technology
  - Heterogeneous Many Core Architecture
  - Designed specifically for wireless application
  - Field proven in various applications

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Introduction – Multicomm SDR platform

- Support of various waveforms and technologies.
  - Modulation schemes, Coding schemes.
  - Multiple access schemes.
  - Bandwidth and bit rates.
- In-the-field upgradability.
- Concurrent operation of multiple standards Waveforms
  - Zero latency re-morphing from one waveform to another
- Competitive in area and power.
- Easy robust development path.
- Scalability: same platform to support a wide range of applications.

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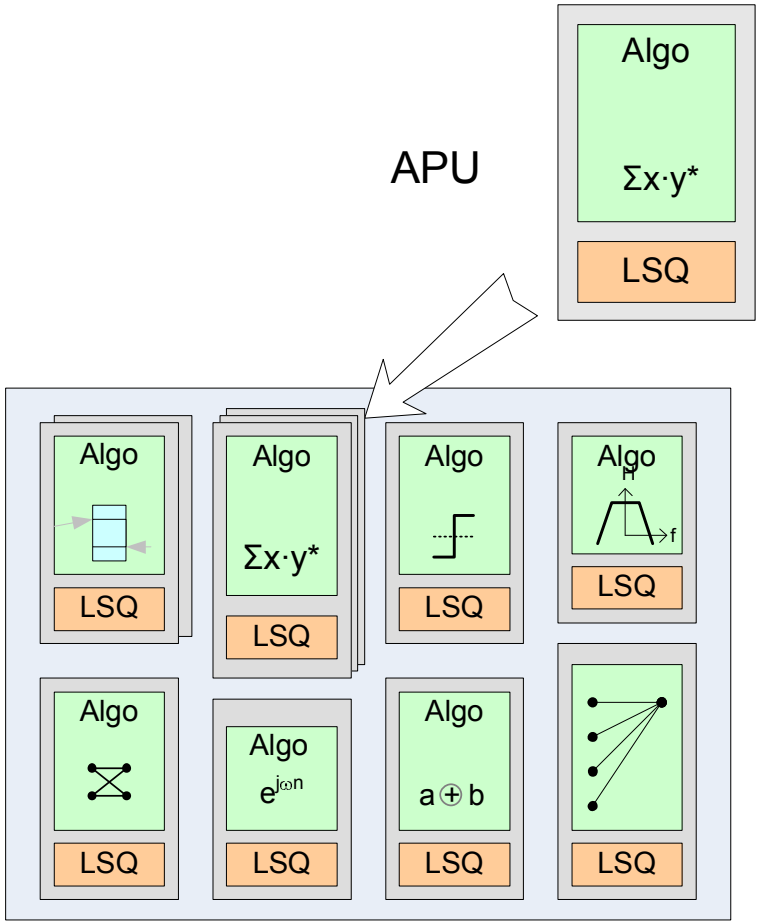
ModemX architecture – Many Core Approach

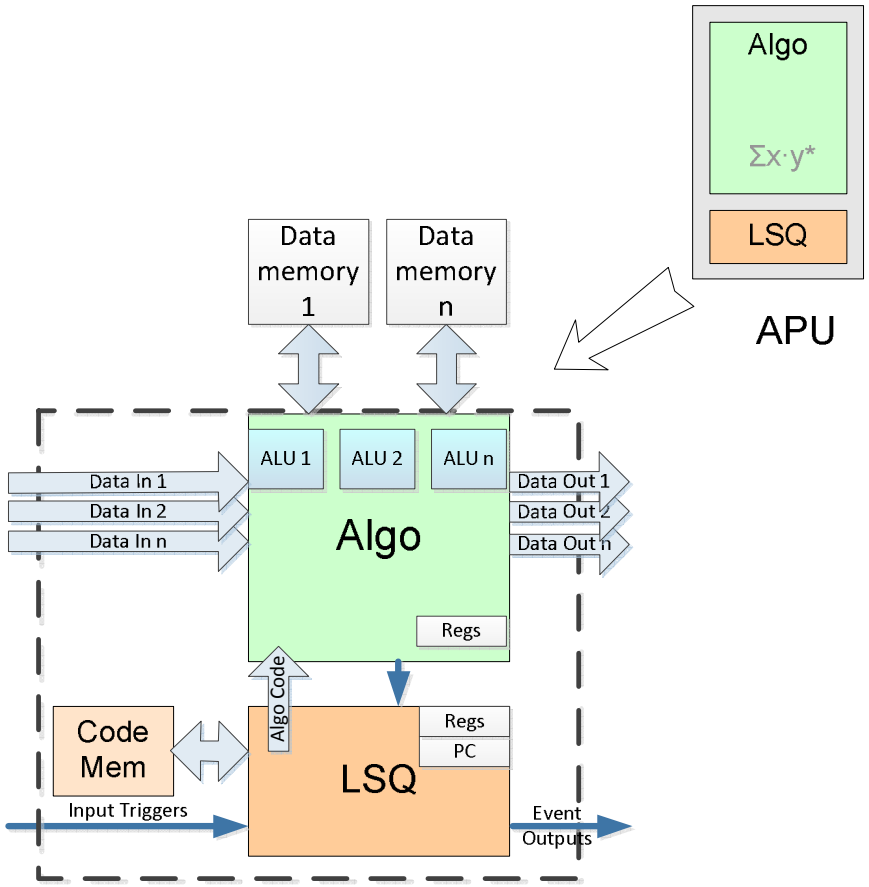
- Heterogeneous Multi/Many Core Architecture.
- Core = Algorithmic Processing Unit (APU).
- Several types of APU.
  - # per type – design parameter
- Each APU is instantiated multiple times.
- 10s-100s of APUs in typical designs.



Processing Elements

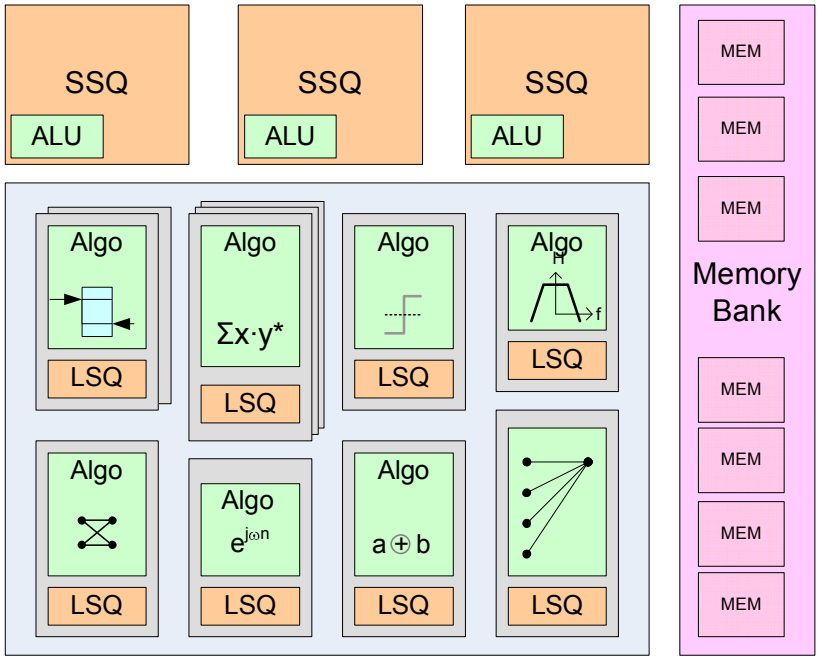
ModemX Architecture – A closer look at APU

- Local Sequencer Unit (LSQ)
  - Algo unit control:
  - Cycle by cycle
  - Configuration
  - Flow control:
  - Nested loops, branch, subroutine calls
- Algorithm Unit
  - Specific to APU type.
  - Efficient dedicated design.
  - Multiple ALUs, registers.
  - Access to Data memory
- Interfaces to other APUs
  - Data
  - Control
  - Handshake signals



ModemX Architecture- SSQ and Memory bank

- Standard Sequencer (SSQ)
  - 16 bit RISC processor
  - High level control
  - APU configuration
  - No participation in Data crunching
  - One for each concurrent standards
  - # - design parameter.
- Memory Bank
  - Pool of single/dual port memories
  - Data for APUs
  - Code Data for SSQs
  - Very high bandwidth interconnect.



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ModemX Architecture - APU Types

- Functional partitioning:
- Result of wide scope survey of wireless communication standards.
- Several APU types: varying in functionality & complexity.
- Some provide a high degree of flexibility and programmability

Memory Gateway APU

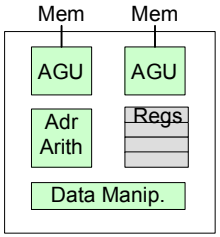
Memory intense operations

Complex memory structures

Interleavers

Delay lines

Sample buffer



MGW APU

Multiply Accumulate APU

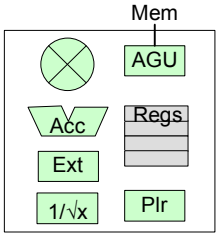
For real/complex signal processing

Multiply/add/extract

Native complex arithmetic

Polar operations

1/x 1/√x, semi - floating point



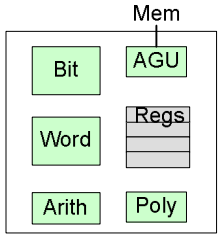
MAC APU

Bit Manipulation APU

For operation on bits and words

Scrambling, Encoding/Decoding

Message construction/parsing



BITMAN APU

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ModemX Architecture - APU Types

- More APU examples
- Ubiquitous operations
- More specific functionality
- Less programmability

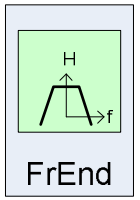
Front End APU

Channel Filtering

Rate conversion

I/Q Correction

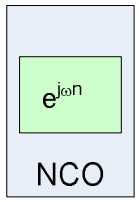
DC correction



Numerically Controlled Oscillator APU

Phase/frequency correction

CORDIC operations

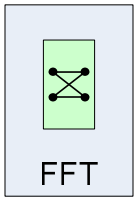


FFT APU

FFT/ IFFT

WHT

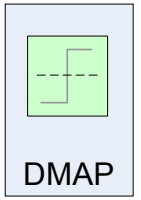
Freq/domain filtering



Demapper APU

QAM slicing

LLR extraction



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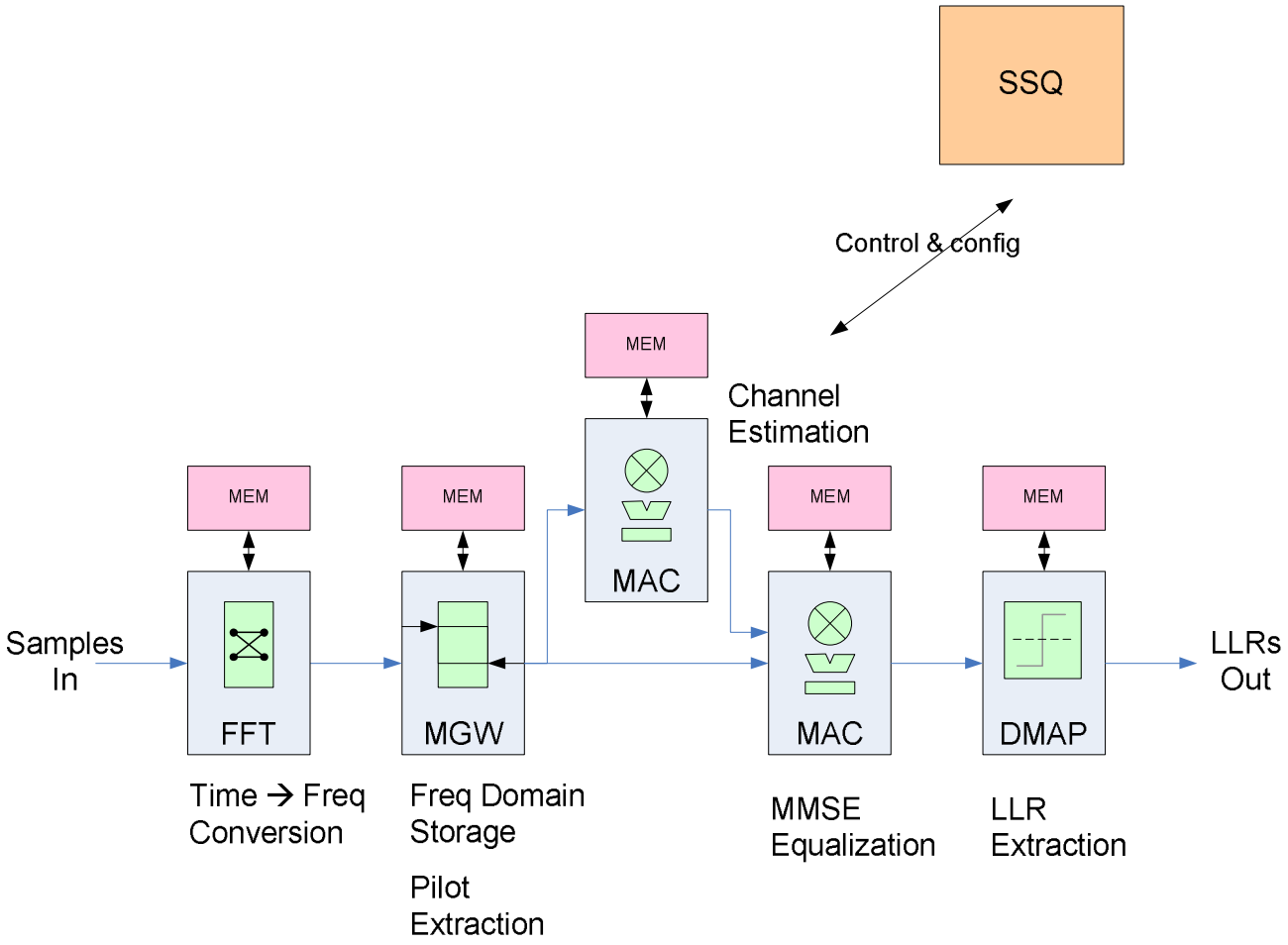
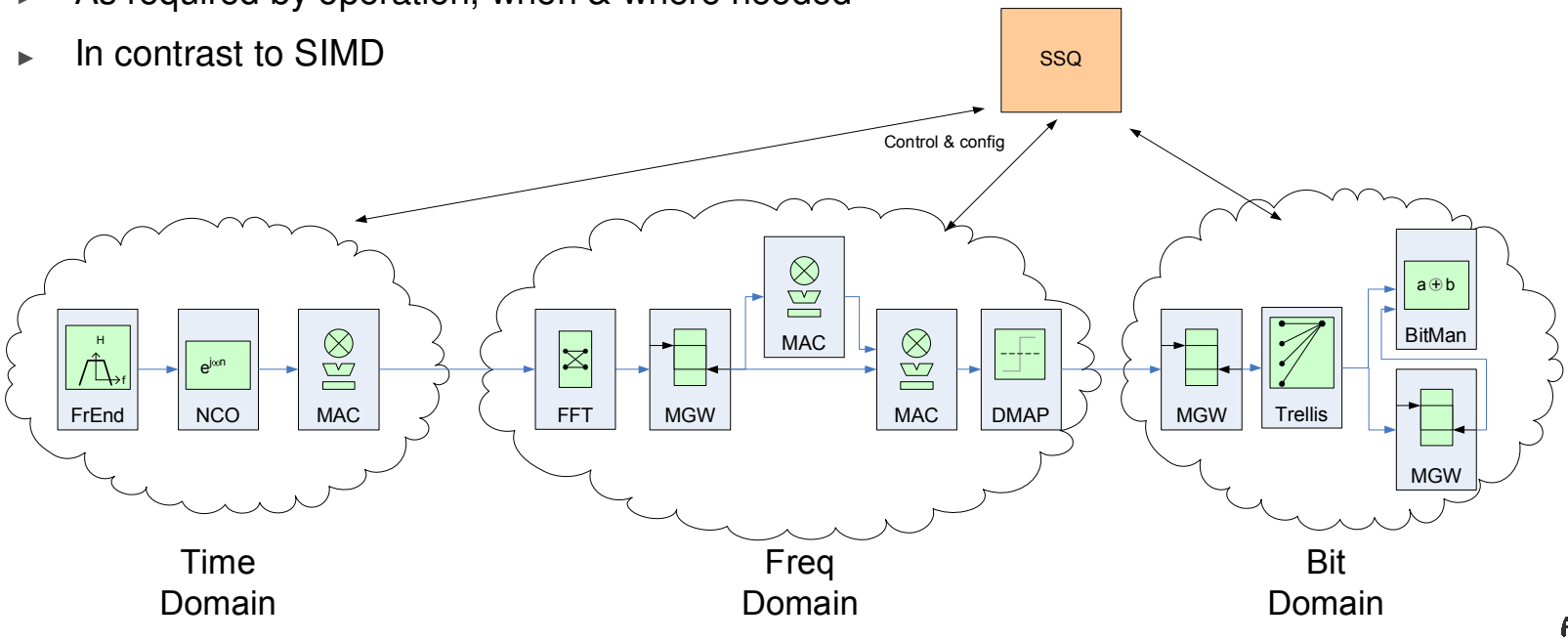
ModemX Architecture - Processing Segment

- Multiple APUs form a Processing Segment
- Example: OFDM Frequency Domain Processing



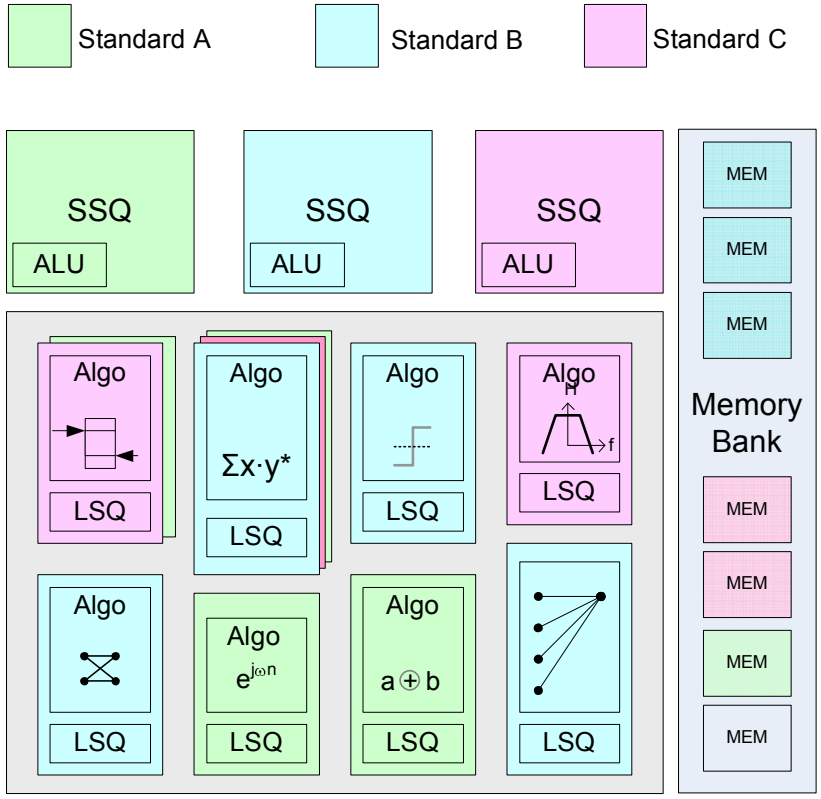
ModemX Architecture - Multiple segments

- Zooming out to a complete design: Multiple processing segments
- Concurrently, or Sequentially
- Multiple Ad-Hoc processors.
  - Each tailored to a specific domain
  - With optimal processing resources
- Significant processing power
  - As required by operation, when & where needed
  - In contrast to SIMD



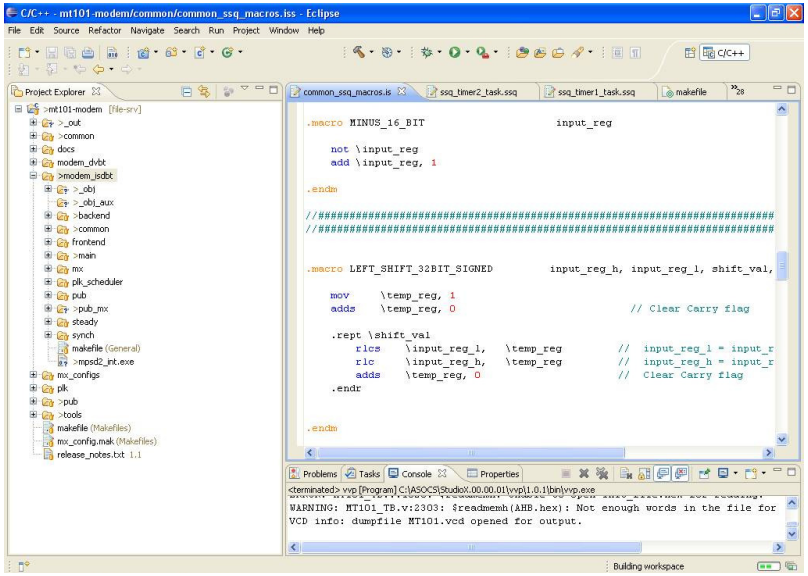
ModemX Architecture - Concurrent operation

- Operation of multiple standards / waveforms
- One SSQ per Standard
- All resources are divided between standards
  - Orthogonal sets
  - No constraints/ bottlenecks between sets
  - Designer may choose to share resources
- New standards/waveforms can be loaded without affecting the currently active ones.

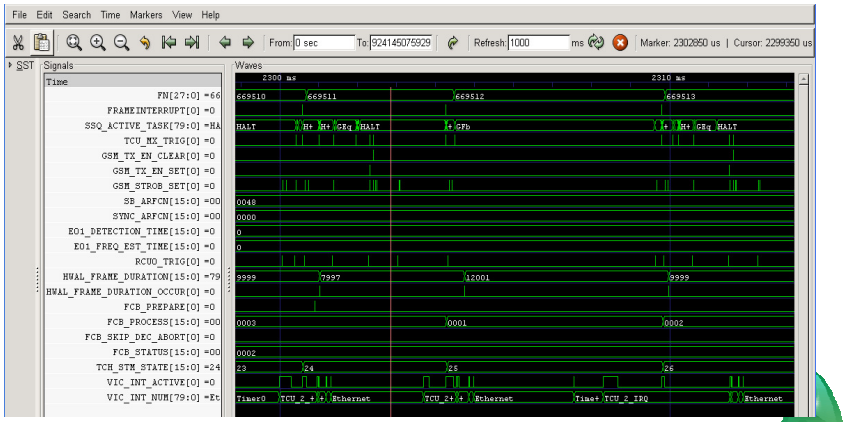


ModemX Development Tools

- Main Challenges
  - **Real time** code development in a **Heterogeneous Many Core** system
  - Programming for **Concurrent Operation**
  - ModemX Architecture abstraction



- Solution
  - StudioX: Integrated Development Environment.
  - MPSD: Multi Protocol System Designer.
  - SSQ/APU Compilers and Assemblers.
  - Real- time debugging and monitoring tools.
  - Function libraries for frequently used algorithms.



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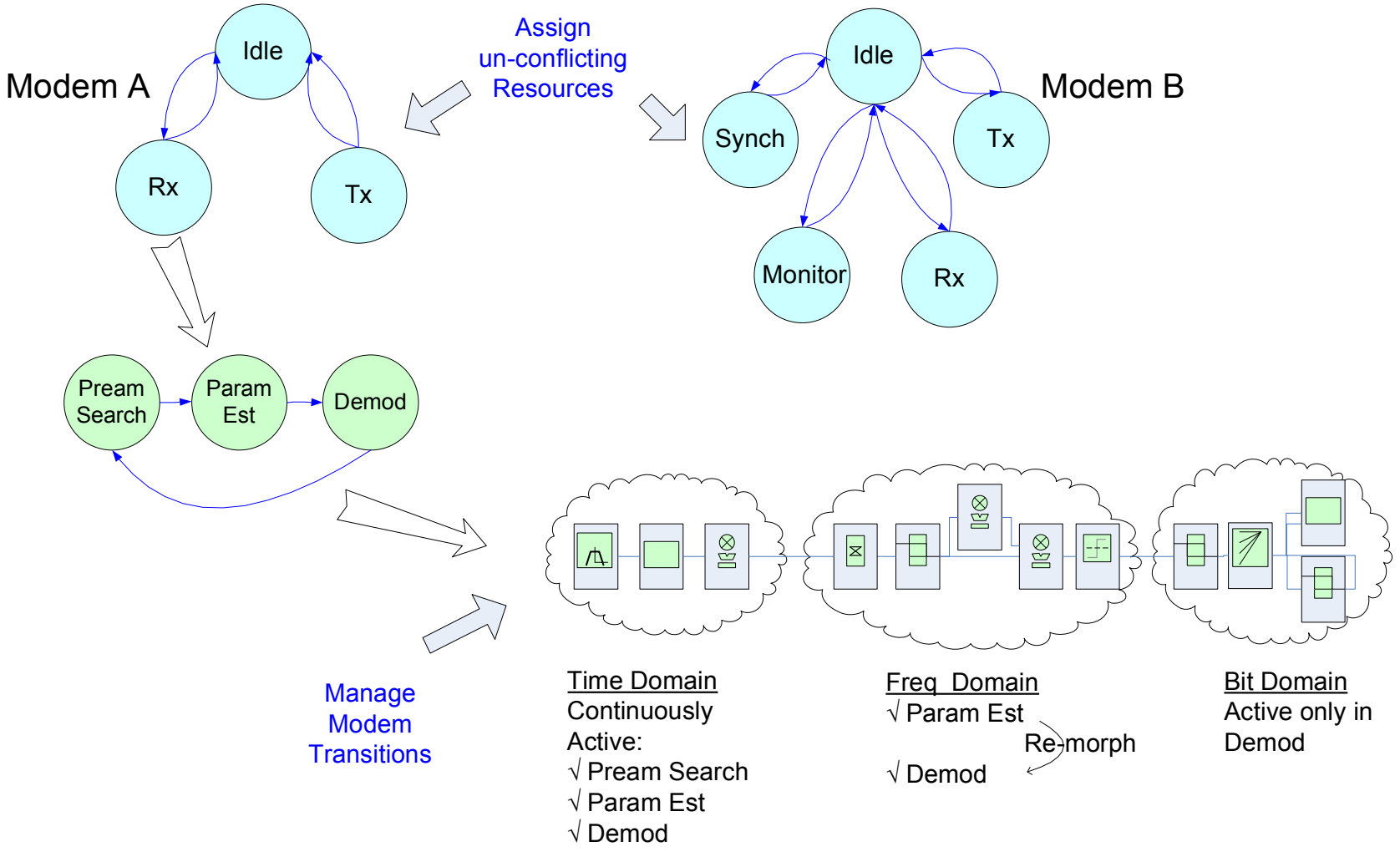
MPSD problem statement



ModemX Architecture - Key points

- Significant Processing power
  - Example LTE (Cat 4 UE)
    - 100 real Multiply accumulate / cycle
    - 50 complex memory transfers per cycle
    - Available for multiple operations across the design
    - Elevates traditional SIMD limitations.
- Power/Area efficiency
  - Data path approach provides near dedicated H/W power consumption
  - Thin control layer
- Scalability
  - Resources are readily tuned to requirements
  - Same platforms for
- One Stop Shop for All processing requirements
  - In contrast to DSP + Accelerator suites

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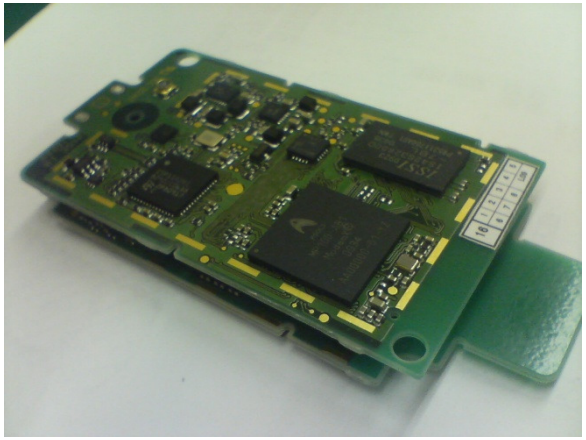
ModemX Applications

- Mobile applications
- Digital TV
- Aerospace
- Infrastructure and Cloud - RAN

Mobile Applications

- Field proven applications developed using ModemX technology
- Implemented on MP100 baseband processor chip:
  - GSM/EDGE
  - TD-SCDMA
  - CMMB (Chinese mobile Digital TV standard)
  - WiFi 802.11g



- Diverse requirements and technologies
  - Bandwidth from 200KHz to 20MHz.
  - Bit rates 240Kb/s – 54 Mb/s
  - Plethora of modulation scheme and demodulation techniques
    - Soft output trellis equalizers (GSM/EDGE)
    - Successive Interference Cancelation joint Detection (TD-SCDMA)
    - OFDM-11g variant: short symbols and burst, fast acquisition time.
    - OFDM-CMMB variant: long symbols, scattered pilots.
- Concurrent operation
  - GSM/ WiFi operation

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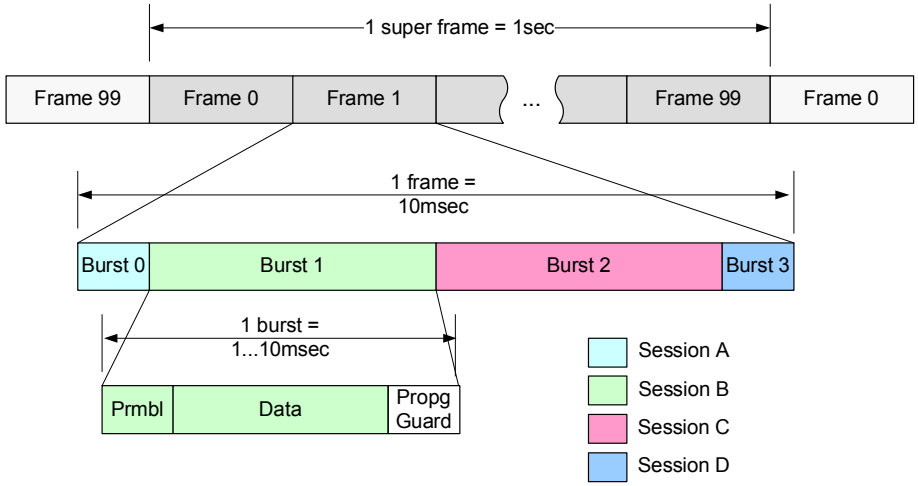
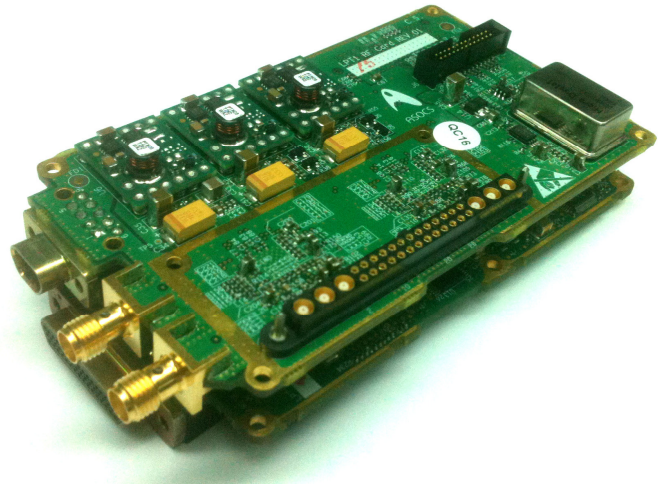
Digital TV applications

- Terrestrial/Satellite Digital TV is an excellent playground for SDR:
- Various regional standards and modulation technologies.
  - DVB-T/T2 (Europe) ISDB (Japan) : OFDM
  - DVB-S/S2 (Europe) Satellite: Single carrier
  - ATSC- ATSC-M/H (USA): Terrestrial, single carrier
  - DTMB- (China) TDS-OFDM
- Receiver configuration and antenna diversity options
- ASOCS MT101
  - ModemX based IP for digital TV

Aero space application

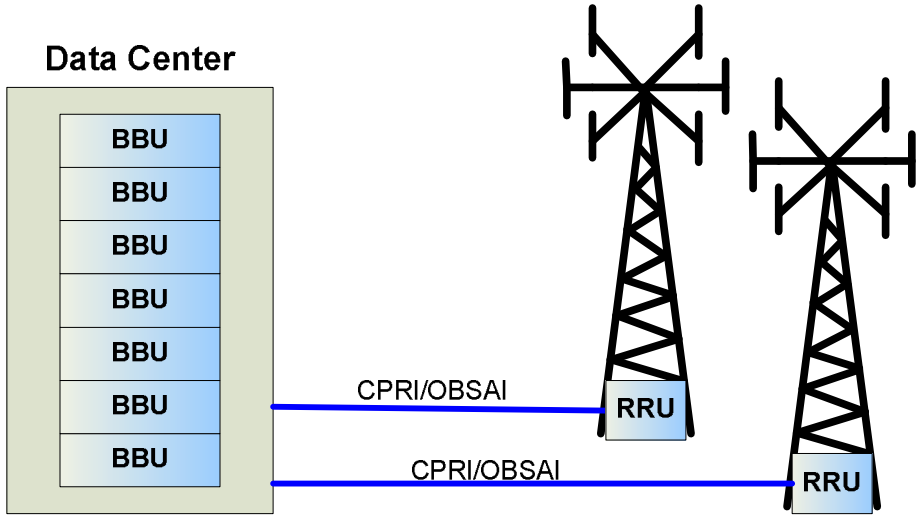
- Developed per requirement of leading Aerospace company
- Two Concurrent Modems, 4MHz, 10Mb/s
- Coded OFDM over frequency hopping
- Small form factor module: 11x6x2.5 cm
- True SDR with a 400MHz- 4 GHz RF transceiver.





Cloud RAN applications

- Cloud RAN Background:
  - Entire C-RAN processing is delegated to the 'cloud'.
  - Implemented in large data centers.
  - On general purpose servers (x86)
- CAPEX reduction
  - economics of scale, GP
- OPEX reduction
  - lower power consumption
- Facilitates novel techniques:
  - Cooperative Multipoint (CoMP) operation



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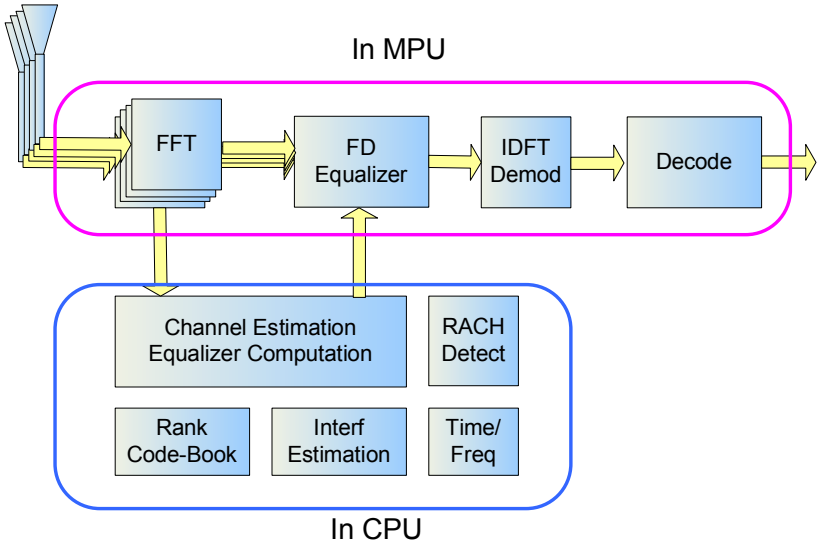
ModemX in cloud RAN

- C-RAN implementation on x86 very challenging
  - High bandwidth/strict latency requirements
  - Processing tasks which are not in x86 architecture
  - E.g. Turbo decoding
  - Data transfers bottlenecks
  - Power efficiency for vector operations
- Proposed approach:
  - CPU off loading to Modem Processing unit (MPU)
  - Implemented using ModemX technology
- Requirements
  - Same solution for 2G,3G 4G
  - Support of complex and irregular algorithm
  - Easy to change and modify data path architecture
  - On the fly re-configurability
  - Power Efficiency



LTE UL reception

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Summary

- Presented ModemX architecture and applications
- New concept and architecture
- Facilitates true concurrent operation
- Powerful and flexible
- Scalable solution, supports a wide range of applications.
- Mobile applications
  - Power and size competitive with dedicated H/W solutions.
- Infrastructure applications
  - High processing for infra structure applications
  - Power consumption well below other SDR solutions.

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Thank you

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