ModemX

Heterogeneous Multi-Core Architecture for SDR Applications
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
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.
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 APU's
  - Code Data for SSQ's
  - Very high bandwidth interconnect.
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

Multiply Accumulate APU

For real/complex signal processing
Multiply/add/extract
Native complex arithmetic
Polar operations
1/x 1/√x, semi - floating point

Bit Manipulation APU

For operation on bits and words
Scrambling, Encoding/Decoding
Message construction/parsing

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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
  ► SSQ/APU Compilers and Assemblers.
  ► Real- time debugging and monitoring tools.
  ► Function libraries for frequently used algorithms.
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
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
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
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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 infrastructure applications
  - Power consumption well below other SDR solutions.
Thank you