Networks in Embedded On-Chip Solutions

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Introduction

Application area:

Complex, fast and precise information processing in measurement domain

Embedded System-on-Chip Solution with FPGA

- Complex design - model based design
- On-chip communication
- Component reuse
- Organisation of data transfer
Former Project: Measuring Machine

- Multi axis closed loop control

Measurement System: NPMM200

- Internal Communication & Synchronization
  - Sequence Control
  - Image Data Compression
  - Sensor Data Correction
  - Position Control

- Interface for Remote PC
- Interface for Imaging Sensors
- Interface for Position Sensors
- Interface for Actuators

Networks in embedded on-chip solutions
Former Project: Measuring Machine

- **Probe Sensor**
- **Probe**
- **Object**
- **Position Sensors**
- **Actuator Systems** (not visible)

Axes:
- $y, \phi_z$
- $z, \phi_x$
- $y, \phi_y$
- $x, \phi_x$
- $x, \phi_y$
- $z, \phi_x, \phi_y$
Former Project: Design Methods

PIM
Platform Independent Model

PSM
Platform Specific Model

Algorithm definition
Platform-independent System Definition

PIM → PSM

Platform-specific Development

Vendor-specific Tool chains

Effective component-specific code generation

Mapping functional to platform structure

Expressing platform properties in model

Defining development platform layer

Capturing hardware properties

Target software components

Distributed hardware
Former Project: Design Methods

Platform-independent System Definition

Platform-specific Development

Vendor-specific Tool chains

Prototyping

Vendor-specific Tool chains

Target abstraction model elements

Platform-specific Development

Distributed hardware

Target components

Vendor-specific Tool chains

Target component

Single processing unit

Profiling

Profile information

Software structure model

Platform structure model

PIM-to-PSM transformation

Platform-specific model

code generation

Target components

Partial algorithm model

Decomposition

Algorithm model

Architecture Mapping

mapping

Distribution model

Performance information

Software structure model

Platform structure model

Platform-specific model

PIM-to-PSM transformation

Vendor-specific model

code generation

Vendor-specific Tool chains

Target component

Distributed hardware

Target abstraction model elements
System-on-Chip Technology

- FPGA – Field Programmable Gate Array
- Reconfigurable Systems-on-Chip
- Universal interfaces needed
- Scalability and high performance
- Reliability by reconfiguration and adaptive routing algorithms
System-on-Chip Technology

On-Chip Communication

- Point-to-Point
- Bus-based
- Network-on-Chip

Complexity of systems → Complexity of interconnections
Network-on-Chip

• Influenced by internet & distributed systems
• Encourage communication-centric design
• Established network technologies
• Flexible network architecture
• Packet based communication
• Decentralized control
• Better reuse of IP-cores

*Embedded Network*
Network-on-Chip

- Core
  - IP-cores, memory, I/O, ...

- Routing Node
  - Routing & Switching
  - Buffering

- Network Interface
  - RINI & RDNI (see next)
  - Packeting / Unpacketing

- Channel
  - Bidirectional links
  - Data lines & control

Example:
2D-mesh-topology
Network-on-Chip

Network Adapter (Resource Network Interface):
Separating communication and processing
Contributions to the design of SoC on FPGA

Network-on-chip and network-on-multiple-chips:

3D-torus network on a multi-FPGA platform (GECKO3STACK)
Contributions to the design of SoC on FPGA

Specialized Soft Microprocessor:
Contributions to the design of SoC on FPGA

Off-chip SoC communication:
Research case study

Requirements:

- Flexibility
- Speed
- Precision
- Security
- Certifiability

Weighing Cell
**Research case study**

Complex and highly efficient information processing in measurement

*Electromagnetic force compensation scale*

- High-speed measurements in a mechanically disturbed environment
- Higher requirements of measurement uncertainty, complexity of algorithms
- Flexible and increasing design
- Certifiable development process
Research case study
FPGA-based implementation of digital data processing

Networks in embedded on-chip solutions
Research case study

Network-on-Chip implementation

- Configuration memory
- FIFO DMA
- Softcore LiSARD control algorithm
- Interface
- Hardware components filter algorithm
- FIFO DMA
- Interface
- Interface
- Interface
- Interface
- Interface
- Interface
- from converter
- from Host
- to Host
- to converter
- to display
- to Host
Summary and outlook

• Solutions for communication in embedded systems
• Focus on System-on-Chip realizations
• Model based design methodology
• Approach using Network-on-Chip principle

Work in progress, next goals:
• Realize and evaluate Network-on-Chip solution
• Apply Requirements Engineering principles

Main goal: Integrated design methodology
Thanks for your attention!