Industrial take-up of asynchronous design

Steve Furber, The University of Manchester

- Outline:
  - Industrial take-up
    - production, research and start-ups
  - The Amulet group
  - Self-Timed Solutions
  - Issues and conclusions

Industrial take-up: production

- Philips
  - 15 years developing Tangram
    - HDL to silicon synthesis route
    - by far the most advanced async tools
  - now engaged in product development
    - 80C51 microcontroller
    - Myna pager chip
    - contactless smartcard chip
Industrial take-up: research

■ Sun
  • very high-speed async pipelines (GaSP)
    – 4GHz on current CMOS process technology
  • exploring novel processor architectures
  • some input to clocked SPARC designs

■ Intel
  • x86 instruction length decoder (1996)
  • async designers influenced P4 clock tree

■ Sharp
  • DDMP media processor

■ IBM
  • Rapid Single-Flux Quantum circuits

■ NTT Network Innovation Laboratories
  • Fully asynchronous self-reconfigurable FPGA
Industrial take-up: start-ups

■ Cogency
  • UK start-up, now based in Toronto
    – initial staff from AMULET group
  • self-timed DSP developed for LG Semicon
  • planned full self-timed ASIC design flow
    – test and static timing tools
  • now moved away from async technology

Industrial take-up: start-ups

■ Theseus
  • US start-up
  • founded by ex-Honeywell engineers
    – ‘re-invented’ async design from scratch
    – little initial contact with established async community
  • Null Convention Logic
  • strong DoD and Motorola contacts
  • significant downsizing in 2001
Industrial take-up: start-ups

- Fulcrum (formerly ADD Inc.)
  - US start-up
  - founded by ex-Caltech students
    - Alain Martin’s group
  - $20 million 2nd round funding secured?
  - Current focus is on network processing
    - fully async design flow

- Myricom
  - Myrinet high-speed switch fabric Ics

- Black Tower
  - asynchronous MIPS core

- Self-Timed Solutions… more later!
Amulet group mission

- to take self-timed (asynchronous) design from academic research into commercial exploitation
  - by developing large-scale VLSI demonstrators
  - by addressing other technical issues as they arise in the course of the research
  - by collaborating with industry to address commercial and market issues

The Amulet microprocessors

- Amulet1 (1994)
  - demonstrated feasibility
- Amulet2e (1996)
  - demonstrated merits
- Amulet3 (2000)
  - demonstrates commercial viability of async SoC design
Amulet3

- a third generation asynchronous ARM
  - performance comparable with ARM9
    - over 100 MIPS (Dhrystone 2.1)
  - ARM architecture v4T
    - includes Thumb decoder
- developed within the OMI ATOM project
  - first application as telecommunications controller subsystem

DRACO

- DECT Radio Communications Controller
  - developed in collaboration with Hagenuk GmbH
  - combines ISDN and DECT telecommunications systems
  - world’s first commercial 32-bit asynchronous SoC product?
Amulet collaborations

- ARM, Inmos
- ARM, GPS
- ARM, Hagenk
- ARM, Hag.
- ARM, Hag.
- ARM, ...

- OMI-MAP
- OMI-HORN
- ARM, GPS
- TAM-ARM
- Philips
- EXACT
- PowerPack
- Balsa
- G3CARD
- DE2
- ATOM
- PREST
- Theseus
- Cogniscience
- GPS (Mitek)
- ACiD working group

Amulet companies

- Cogency Technology, Inc.
  - founders included Amulet research staff
  - still trading, though not in async technology
- Cogniscience Ltd
  - neural network research
  - will use async technology, probably
- Self-Timed Solutions

Summary

- Only Philips & Myricom have async products
- Major companies are keeping watch
  - Sun, Intel, IBM, Sharp, Infineon, …
- Start-ups appear from time to time
  - Cogency, Theseus, Fulcrum, STS, …
  - but no sustainable async business yet

*Conclusion: async design is still a fringe activity*
### Why is async a fringe activity?

- **It’s different**
  - designers are very used to clocked design
- **It’s hard**
  - thinking about asynchronous concurrency requires a new mindset
- **It’s poorly supported**
  - most CAD tools assume clocks are used
- **Its ‘value proposition’ is insufficient**
  - all the above can be overcome, but do the benefits justify the cost of doing so?

### When might async take-off?

- **When the value proposition is strong!**
  - research is reducing the cost
    - Tangram, micropipelines, Petrify, Balsa, NCL...
  - technology is increasing the benefit
    - demand for lower power & higher performance
    - difficulty of clocking large processors and SoCs
    - EMC
    - security (immunity to power and EM analysis)
    - RSFQ 100 GHz operation
      - makes clocking virtually impossible!
Possible paradigm shift

- GALS - Globally Asynchronous Locally Synchronous - systems
  - clocked modules
    - supports conventional design flow
  - with asynchronous on-chip interconnect
    - e.g. CHAIN ‘chip-area network’
  - solves large SoC clock distribution problem
    - future SoCs will have hundreds/thousands of IP blocks and complex interconnect topologies

Conclusions

- Async technology:
  - offers significant benefits at significant cost
  - is still a fringe activity
- The ‘value proposition’ is improving
  - costs falling, benefits growing
- A successful async company must be
  - in the right business
  - with the right technology
  - at the right time