Transputers
The Lost Architecture

Bryan T. Meyers

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What is a Transputer?

Definition

Transputer stands for "TRANSmitter and comPUTER", combines a computer processor with high-speed serial links.

Features (T225)

- 16-bit Microprocessor
- 30 MHz Clock
- Four-phase Logic
- 4KB SRAM
- 4 serial links (5/10/20 Mb/s)

Figure: Multi-Transputer Module
History

- 1978 - INMOS created by British Government
- 1985 - First Transputer is Introduced
- 1989 - Transputers are the most widely RISC processor
- 1990 - Over 500,000 Transputers shipped

Figure: T400 Processor Die
## Models

**Table:** Comparison of Popular Transputer Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Bits</th>
<th>Clock (MHz)</th>
<th>SRAM (KB)</th>
<th>Link Speed (Mbps)</th>
<th>Floating-Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>T225</td>
<td>16</td>
<td>30</td>
<td>4</td>
<td>20</td>
<td>—</td>
</tr>
<tr>
<td>T400</td>
<td>32</td>
<td>20</td>
<td>2</td>
<td>20</td>
<td>—</td>
</tr>
<tr>
<td>T425</td>
<td>32</td>
<td>25</td>
<td>4</td>
<td>20</td>
<td>—</td>
</tr>
<tr>
<td>T805</td>
<td>32</td>
<td>25</td>
<td>4</td>
<td>20</td>
<td>Yes (1/8 Speed)</td>
</tr>
<tr>
<td>T9000</td>
<td>32</td>
<td>20</td>
<td>16</td>
<td>80</td>
<td>Yes (1/10 Speed)</td>
</tr>
</tbody>
</table>
Architecture Overview

Figure: T425 Architecture
Four-phase Logic

**Figure:** Connected 1 to 3 Latch

**Figure:** Latch Paths

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Transputers

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Occam

Features
- Communicating Serial Processes
- Primitives: Channels, Processes
- Explicit Sequential and Parallel Execution

Sequential Code

SEQ
\[
\begin{align*}
x & := x + 1 \\
y & := x \times x
\end{align*}
\]

Parallel Code

PAR
\[
\begin{align*}
p () \\
q ()
\end{align*}
\]
What is a Transputer?

**Architecture**

**TRAMs**

**TRAM:**
- Multiple Transputers per card
- Multiple Cards per Computer
- High Speed Fabric
- Shared Power

*Figure: IBM TRAM*
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Notable Consumer Transputers

Atari Transputer Workstation
- T800 Transputer
- up to 12 more Transputers
- up to 130 MIPS (Very Fast)
- 4MB of RAM, Upgradeable to 16
- HeliOS
- 1989 release date
- only 350 made
Virtual Reality

INMOS Multiplayer Flight Simulator

- T800 Transputers
- 22 Frames per Second
- up to 4 players
- Joystick controls
- ring bus to communicate between displays
- rendering pipeline per user
- 1987 SIGGRAPH
High Performance Compute

Features

- Over 10 Nodes
- SW Defined Network Topology
- Compute or Graphics Boards
- Distributed RAM
- Upgradeable
- Heterogeneous
- Pioneered MIMD Design

Figure: Meiko Computing Surface Cabinet
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Idea:
There exists a single computational element which, when combined with other identical units, can be used to build or emulate any computer architecture.
Universal Compute Element

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Requirements:
- Must perform both Integer and Floating-Point calculation
- Must have local memory, without direct access to global memory
- Must be able to communicate with other elements
Universal Compute Element

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Hypothesis
The Transputer is able to behave as a Universal Compute Element.
Flynn’s Taxonomy: Overview

**SISD**
- Sequential
- Single Processing element
- One Data Stream
- One Instruction stream
Flynn’s Taxonomy: Overview

SISD
- Sequential
- Single Processing element
- One Data Stream
- One Instruction stream

SIMD
- Data Parallel
- Multiple Processing Elements
- Multiple Data Streams
- One Instruction Stream
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**MISD**
- Instruction Parallel
- Multiple Processing Elements
- One Data Stream
- Multiple Instruction Streams
Flynn’s Taxonomy: Overview

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**MIMD**
- Completely Parallel
- Multiple Processing Elements
- Multiple Data Streams
- Multiple Instruction Streams
Flynn’s Taxonomy: SISD

SISD
- Sequential
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Figure: SISD using Universal Compute Elements
Flynn’s Taxonomy: SIMD

**SIMD**
- Data Parallel
- Multiple Processing Elements
- Multiple Data Streams
- Single Instruction Stream
Flynn’s Taxonomy: MISD

- Instruction Parallel
- Multiple Processing Elements
- Single Data Stream
- Multiple Instruction Streams
Flynn’s Taxonomy: MIMD

- Completely Parallel
- Multiple Processing Elements
- Multiple Data Streams
- Multiple Instruction Streams
Transputers Today

IBM Blue Gene:
- Multiple PowerPC Processors per card
- Multiple Cards per Node
- Multiple Nodes per Rack
- Multiple Racks
- High Speed Fabric
- Shared Power

Figure: IBM Blue Gene L

Legacy
Transputers Today

HP Project Moonshot:
- 1-8 Cores per Processor
- 1-4 Processors per card
- Up to 45 Cards per Chassis
- Up to 10 Nodes per Rack
- Multiple Racks
- High Speed Fabric
- Shared Power

Figure: Hp Moonshot
Tilera Tile Processors:
- 9-72 Cores
- up to 1TB of RAM
- Over 100 Mbps between Cores
- Up to four 20Gb Network Links
Transputer Influence on Modern Design

Processor Design
- 2 or 4 Phase Pipelined Logic
- High Speed Serial Links (HyperTransport, QPI)
- Network on Chip
- System on Chip

Hyperscale
- Hundreds of processors
- Different Configurations by Task
- Shared Power, Disk, Network
- Single Box

Parallel Programming
- $\pi$ Calculus
- Communicating Sequential Processes
- Message Passing
Links

- Transputer (Princeton)
- Occam (Programming Language)
- The Transputer FAQ
- Ram’s Transputer Home Page
- Atari Museum
- Meiko Computing Surface
- Flynn’s Taxonomy