Two Dimensions of Model-Based Design

System Composition

- Ptolemy
- SL/SF
- VS
- ESPRAL
- Composable
- Integrated
- Correct by construction

Tool Composition

Single Tools → Customizable Frameworks → Composition Frameworks

- Heterogeneous Networked Embedded Systems

Advances In MIC Tools for Networked Embedded Systems Applications

Edited and Presented by
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ISIS, Vanderbilt University
# System Composition Approaches

<table>
<thead>
<tr>
<th>Component Behavior</th>
<th>Structure</th>
<th>Interaction</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee /Ptolemy II</td>
<td>Hierarchical Module Interconnection</td>
<td>Heterogeneous Models of Computation + Directors</td>
<td>Java Code/ Behavioral Models</td>
</tr>
<tr>
<td>Henzinger /Giotto</td>
<td>Hierarchical Module Interconnection</td>
<td>-Interface Theory; -Resource Interfaces</td>
<td>Java/C++ Code</td>
</tr>
<tr>
<td>ASV /Metropolis</td>
<td>Netlists: Hierarchical Module Interconnection</td>
<td>-Giotto: TT Static Periodic Schedule</td>
<td>Processes: Java Objects</td>
</tr>
<tr>
<td></td>
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<td>Media: Heterogeneous MoC-s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Composable Schedulers</td>
</tr>
</tbody>
</table>

# Tool Composition Approaches

<table>
<thead>
<tr>
<th>Domain-Specific Tools; Design Environments</th>
<th>Prototype Tool Chains (Software factories) (work in progress):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• ECSL - Automotive</td>
</tr>
<tr>
<td></td>
<td>• ESML - Avionics</td>
</tr>
<tr>
<td></td>
<td>• SPML - Signal Processing</td>
</tr>
<tr>
<td></td>
<td>• CAPE/eLMS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metaprogrammable Tools, Integration Environments</th>
<th>MIC Metaprogrammable Tool Suites: (mature or in maturation program):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• GME (Generic Model Editor)</td>
</tr>
<tr>
<td></td>
<td>• GReAT (Model Transformation)</td>
</tr>
<tr>
<td></td>
<td>• OTIF (Tool Integration Framework)</td>
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<td></td>
<td>• UDM (Universal Data Model)</td>
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<td>• DESERT (Design Space Exploration)</td>
</tr>
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<td>• GME-MOF/Meta (Metamodeling Env-s)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semantic Foundation</th>
<th>MIC Foundations (work in progress):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Semantic Anchoring Environment (SAE)</td>
</tr>
<tr>
<td></td>
<td>• Architecture Exploration Platform (AEP)</td>
</tr>
</tbody>
</table>
### Interrelations

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<thead>
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<th>Component Behavior</th>
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</tr>
</thead>
<tbody>
<tr>
<td>- State Automaton</td>
<td>- Set-Valued Semantics</td>
<td>- Tagged Signal Model</td>
<td>- Transition Systems With Priority</td>
</tr>
<tr>
<td>- Timed Automaton</td>
<td>Abstract Syntax + Semantic Anchoring</td>
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<td>- Hybrid Automaton</td>
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</tr>
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<td>Domain-Specific Tools, Tool Chains</td>
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### Networked Embedded Systems Challenges

- **Fine-grain NEST applications**  
  (shooter location, Berkeley mote-based)  
  - New ranging method + improved self-localization
- **Heterogeneous large-scale networked embedded system applications (FCS)**  
  - Drastically increased model complexity  
  - Significant need for semantic foundations for metamodelling  
  - Shift toward dynamic architectures
Radio Interferometric Ranging

- COTS radio chip (CC1000 on MICA2)
  - transmit frequency: 400-460 MHz
  - wavelength: 65 cm < \lambda < 75 cm
  - adjustable in 64 Hz steps
- Two senders (A and B) transmit simultaneously
  - frequency separation: 100-800 Hz
  - duration of transmission: 32 ms
- Several receivers (C, D and E) measure interference
  - sample radio signal strength at 8.9 kHz
  - beat frequency: 100-800 Hz
  - samples per beat: 10-80
  - beats per transmission: 3-25
  - use time synchronization with 1 \mu s precision to correlate phase offsets
  - result is \((d_{AD} - d_{BD} + d_{BC} - d_{AC})\) modulo \lambda
- relative phase offset of beat frequency
  \[ = (d_{AD} - d_{BD} + d_{BC} - d_{AC}) \mod \lambda \]
where 65cm < \lambda < 75cm

(Maroti, Ledeczi, 2005)

Multiuser Access and Model Versioning in GME

- Cache file storing all relationships locally
- Objects are not locked until user attempts to modify them
- Upon a modification attempt the model is checked out from the server
- Model consistency must be ensured at all times; Models have very rich interrelationships
  - the containment hierarchy and the type inheritance hierarchy form two orthogonal trees. Reference chains cut across these hierarchies.
  - Strict locking policy must be enforced.
- The following relationships are followed recursively to check out the target objects also:
  - All children (and consequently all descendants) in the containment hierarchy
  - All references are followed in the reference chain all the way to the final target
  - All derived types and instances are followed in the inheritance hierarchy
- GME ensures that
  - Checked in models are consistent at all times
  - All available previous versions are consistent also
Metaprogrammable Tool Suite

Generic Model Editor

Design Space Exploration

GME

Unified Data Model

Model Transformation

UDM

Open Tool Integration Framework

OTIF

Meta Models

- Simulators
- Verifiers
- Model Checkers
- Generators

Semantic Foundation for Metamodelling

- Set-valued Semantics for Metamodels (Ethan Jackson)
  - Structural semantics for models

- Semantic Anchoring for DSML-s (Kai Cheng)
  - Specification of “Semantic Units”
  - Operational semantics
  - Asml