The Timed Asynchronous Model
and it’s Application
in Time-Triggered Protocols

Ruiqi Hu

May 2, 2000
Previous Work

• Timed Asynchronous (TA) Model
  – Asynchronous communication network
  – Probabilistic clock synchronization

• Time-Triggered Protocols (TTPs)
  – Dedicated, synchronous communication network
  – Hardware supported clock synchronization
A Hybrid System Model

• **Goal:** to provide a quasi-synchronous interface for asynchronous systems.

• **System** consists of *clusters* of processors.

• **Intra-Cluster Communication** is synchronous.

• **Inter-Cluster Communication** is asynchronous.

• **Gateway** is the interface processor between a cluster and the rest of the system.
Clock Synchronization

• Processors in a cluster synchronize to their gateway.

• Gateways are internally/externally synchronized.

• Probabilistic clock synchronization is used to achieve inter-cluster synchronization.
Probabilistic Clock Synchronization

- $T' \in [T + \text{min}(1 - \rho), T + 2D(1 + 2\rho) - \text{min}(1 + \rho)]$

- Best estimate: $T + D(1 + 2\rho) - \text{min} \cdot \rho$

- Precision: $D(1 + 2\rho) - \text{min}$
Asynchronous Behavior

Round-trip delay measured at different network loads (30,000 samples)

Heavy load ——
Light load  ••••••
Adaptive Clock Synchronization

- Synchronization probability and precision depend on the chosen of round-trip timeout $2U$.
- A slave processor increases/decreases $U$ when it observes the increasing/decreasing of network load.
- More consecutive timeouts $\Rightarrow$ increasing network load observed.
- Round-trip delay consistently smaller than a given value (which is smaller than $2U$) $\Rightarrow$ decreasing network load observed.
## Simulation Results

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Light Load</th>
<th>Heavy Load</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Probabilistic Protocol</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>failure #</td>
<td>107/45068</td>
<td>3125/16194</td>
</tr>
<tr>
<td>failure percentage</td>
<td>0.24%</td>
<td>19.30%</td>
</tr>
<tr>
<td><strong>Adaptive Protocol</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>failure #</td>
<td>23/45227</td>
<td>578/22696</td>
</tr>
<tr>
<td>failure percentage</td>
<td>0.05%</td>
<td>2.55%</td>
</tr>
</tbody>
</table>

Round-trip timeout $2U = 280$ ms, $k = 4$. 
Conclusions

• Hybrid system model could provide quasi-synchronous semantics for asynchronous systems.

• Adaptive clock synchronization protocol improves synchronization quality significantly.