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

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Previous Work

- Timed Asynchronous (TA) Model
  - Asynchronous communication network
  - Probabilistic clock synchronization
- Time-Triggered Protocols (TTPs)
  - Dedicated, synchronous communication network
  - Hardware supported clock synchronization

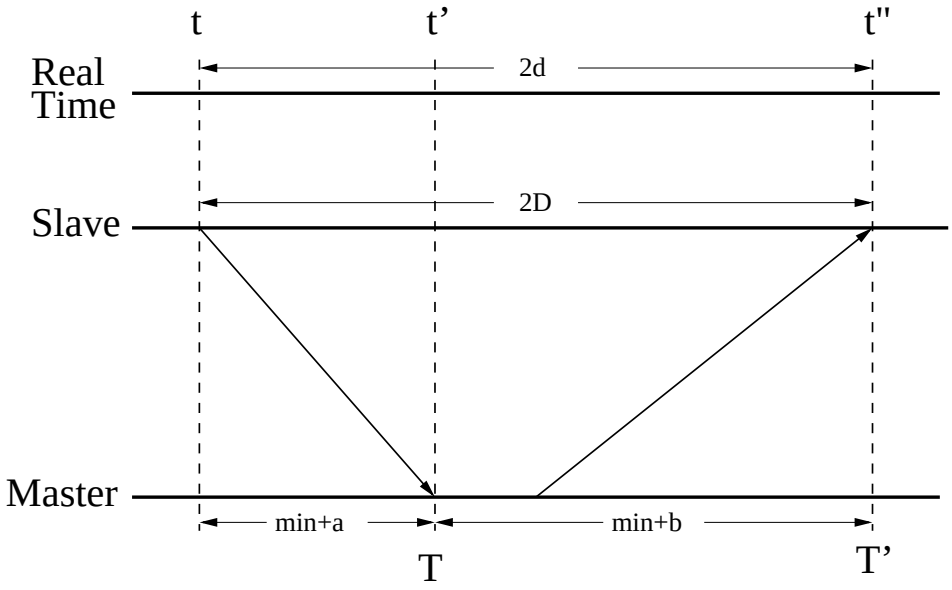
A Hybrid System Model

- **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

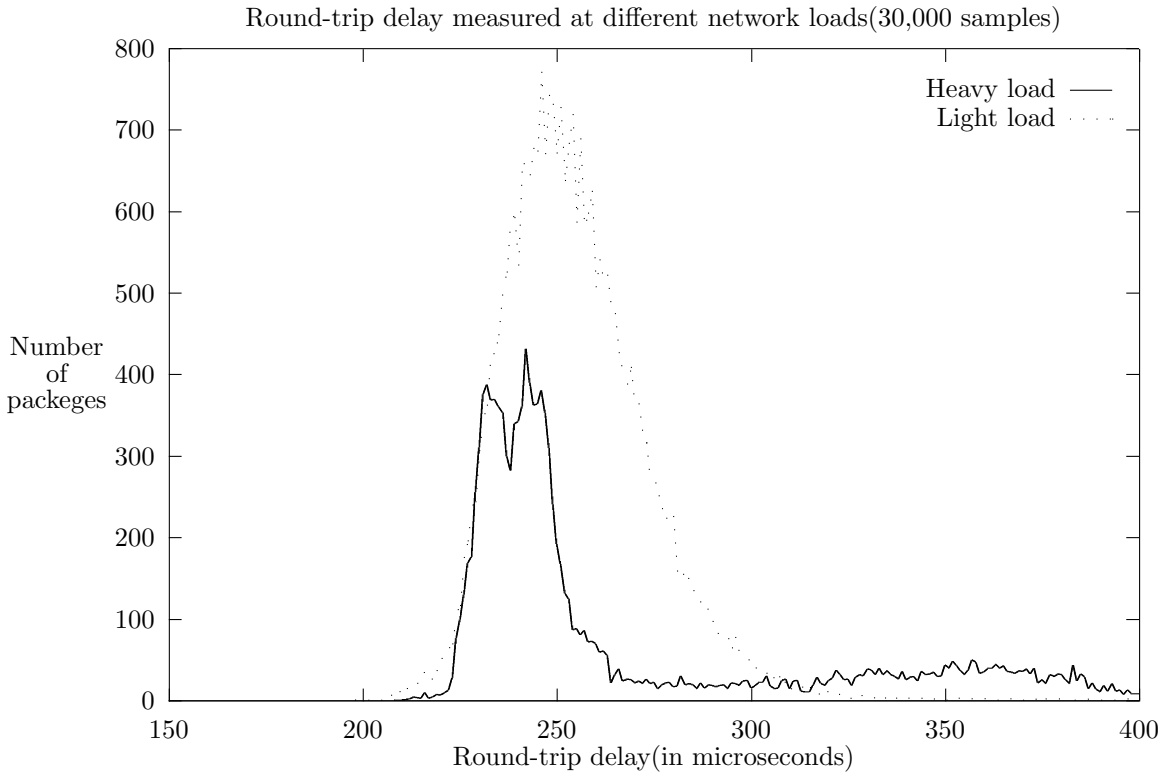
- Processors in a cluster synchronize to their gateway.
- Gateways are internally/externally synchronized.
- Probabilistic clock synchronization is used to achieve inter-cluster synchronization.

Probabilistic Clock Synchronization



- $T' \in [T + min(1-\rho), T + 2D(1+2\rho) - min(1+\rho)]$
- Best estimate$= T + D(1+2\rho) - min \cdot \rho$
- Precision $= D(1+2\rho) - min$

Asynchronous Behavior



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

	Light Load	Heavy Load
Probabilistic Protocol		
failure #	107/45068	3125/16194
failure percentage	0.24%	19.30%
Adaptive Protocol		
failure #	23/45227	578/22696
failure percentage	0.05%	2.55%

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

Conclusions

- Hybrid system model could provide quasi-synchronous semantics for asynchronous systems.
- Adaptive clock synchronization protocol improves synchronization quality significantly.