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Evaluation of Parallel Design Patterns for Message Processing Systems on Embedded Multicore Systems

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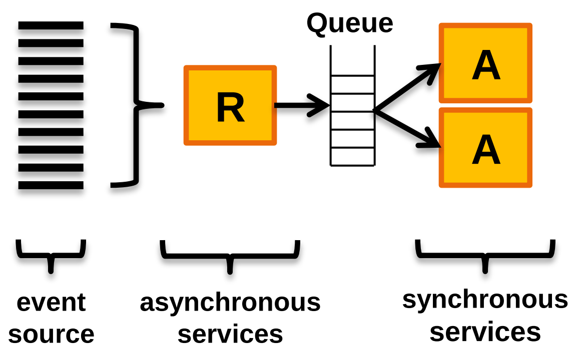
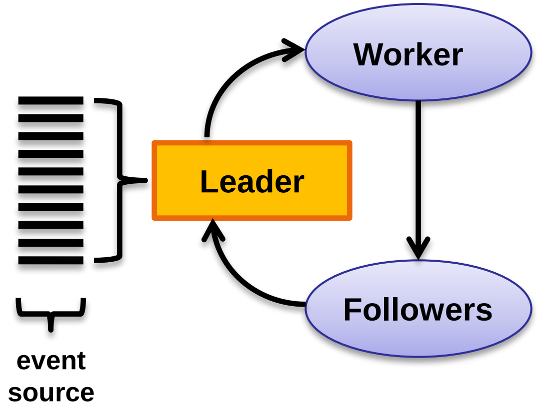
Motivation

- Design patterns reflect engineering practice and experience, but
- Complexity and performance implications often unknown
- Several patterns exist for event processing:
  - Reactor
  - Half-Sync/Half-Async
  - Leader/Followers
  - Proactor
- All patterns have been evaluated before
  - But never in the same context
  - Always under a specific application
  - Not on multicore systems
- Our aim:
  - Evaluation of all patterns in the same application-agnostic context
  - On embedded multicore system

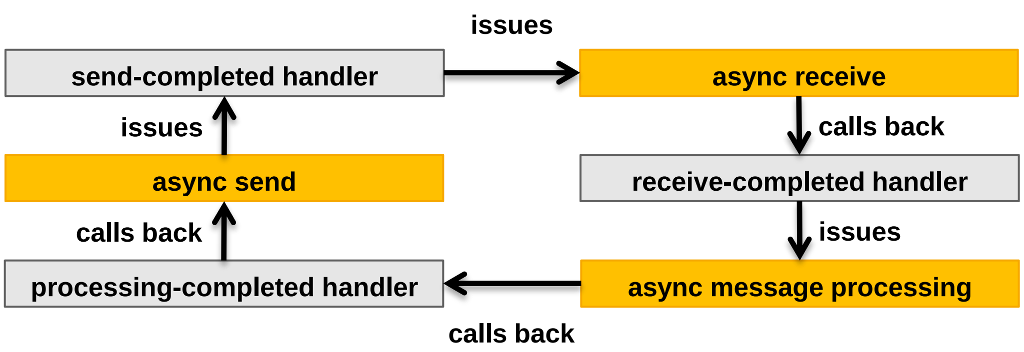
- Thread-per-Connection (multi-threading strategy)
  - Each thread serves one connection exclusively
  - Thread terminates after connection was torn down
- Reactor (pattern)
  - Single threaded → avoids all multithreading overhead
  - Used in Half-Sync/Half-Async & Leader/Followers
- Half-Sync/Half-Async (pattern)
  - Distinguish between asynchronous and synchronous services
  - Asynchronous services are triggered by external event sources
  - Synchronous services poll a queue and processes data further



- Leader/Followers (pattern)
  - Threads take turn accessing the set of event sources
  - At most one thread is Leader
  - Idle threads are Followers waiting to become Leader



- Proactor (pattern)
  - Uses asynchronous I/O and message processing



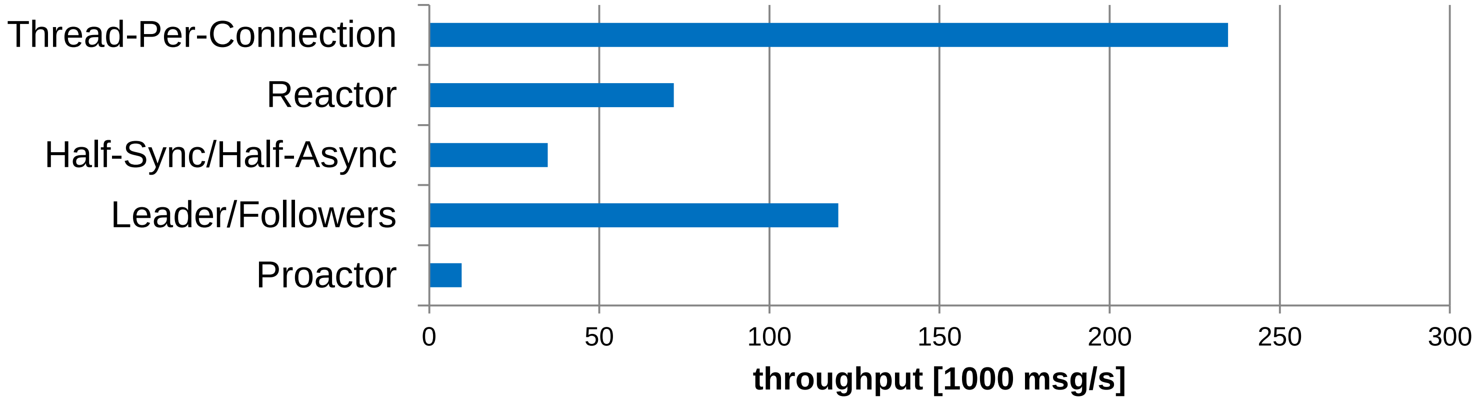
Evaluation Settings

- Evaluation system
  - Cavium Octeon Plus CN5650
    - 12 MIPS cores @ 800MHz
    - Designed for embedded telecommunication applications

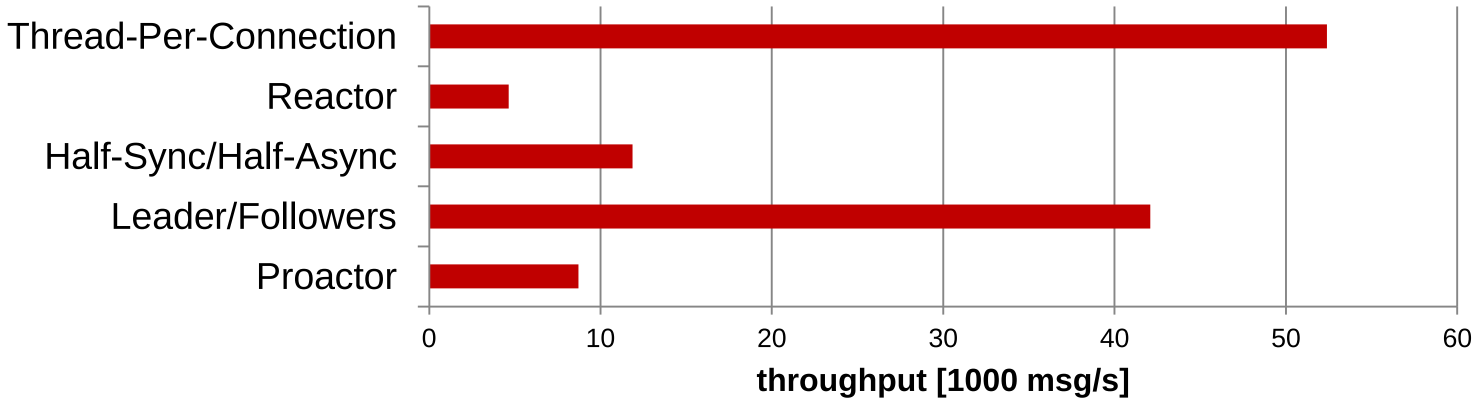
- Measurement settings
  - 128 TCP connections maintained by 2 threads
  - Messages are1 byte long
  - With 1 - 12 threads (Half-Sync/Half-Async, Leader/Followers, Proactor)
  - With 1 – 12 cores (Thread-per-Connection)
  - Additional work load per message of 0 to 200 µs

Evaluation Results
Peak performance

- No additional load per message

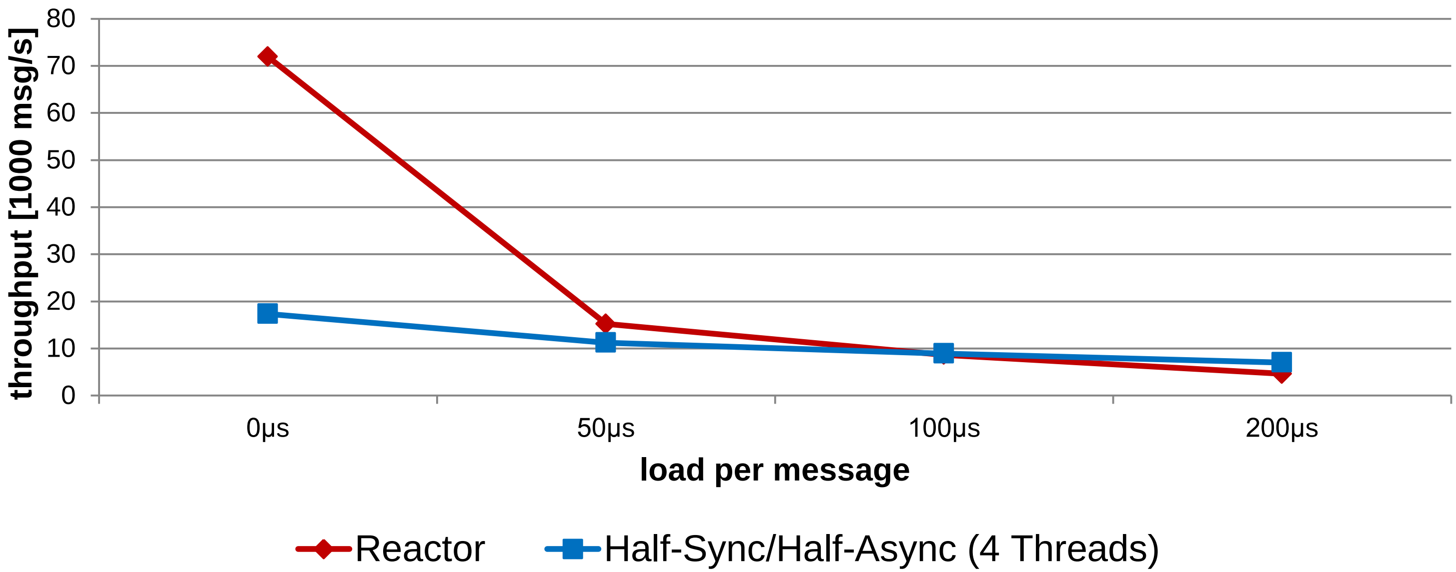


- 200µs load per message



Evaluation Results
Half-Sync/Half-Async pattern

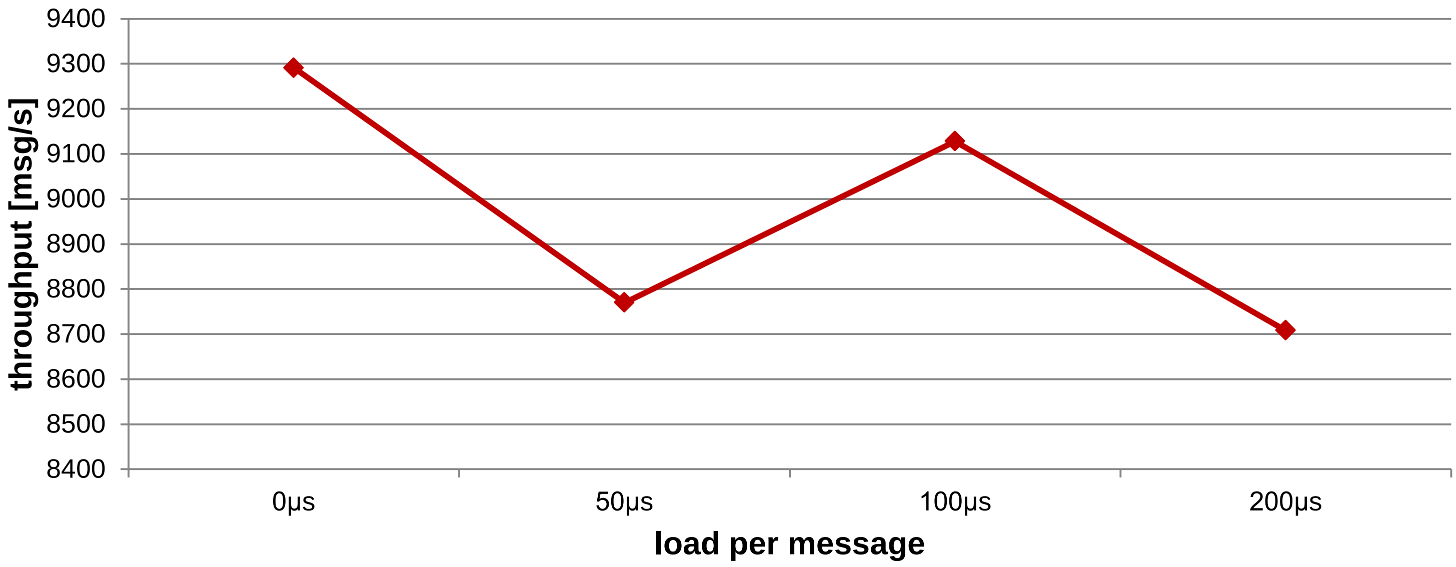
- Comparison of Half-Sync/Half-Async with 4 threads against Reactor pattern
  - Low throughput caused by asynchronous service (implemented using Reactor pattern)
  - →More frequent invocation of event de-multiplexing induces high latency



Evaluation Results
Proactor pattern

- Proactor with 2 threads
  - Increasing load does not decrease throughput → limited by I/O

→One thread created for each I/O completion handler



Lessons learnt & Future Work

- Lessons learnt so far
  - Considerable performance differences between patterns
  - Distribute event de-multiplexing over multiple threads
  - Distribute event sources as well
    →Avoiding the bottleneck of a single thread
  - The wrong multi-threading architecture is worse than none
    →Reactor partly performed better than Half-Sync/Half-Async

- Future Work
  - Include:
    - Shared resources,
    - Connection establishment / termination overhead etc.
  - Use alternative I/O primitives (epoll) and mechanics (POSIX signals)
  - Expand measurement with CPU utilization, cache usage etc.