ETH
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Systems@ETH Zürich

# Unifying Synchronization and Events in a Multicore OS

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  - Structure OS as a distributed system
  - No shared state between nodes

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- However facing similar problems as in classical dsitributed systems within OS
- Services and applications on nodes execute independently
  - Still perform a common task
  - Need to be coordinated

# Motivation: Waiting for dependencies

- Waiting for dependencies
- “Solution”
  - Store known fact “instance_done”
  - Depending process queries for this fact
- Typical pseudo code in Barrelfish:

```
while (not(“instance_done”)) {
    query(“instance_done”);
    thread_yield();
}
```

- Used to wait for termination of dependent processes
- Coordinate system bootup
- Used to resolve driver dependencies
  - NIC driver must wait for PCIe driver to initialize PCIe bus

# What do we need?

- Need ability to store information
- Need notification about new information, rather than while loop

# What do other people do?

- Apache Zookeeper
- Google Chubby
- Redis

# Within same machine

- Different environment
  - Reliable interconnect
  - No single CPU failures within machine
- Decided to go for simple centralized service

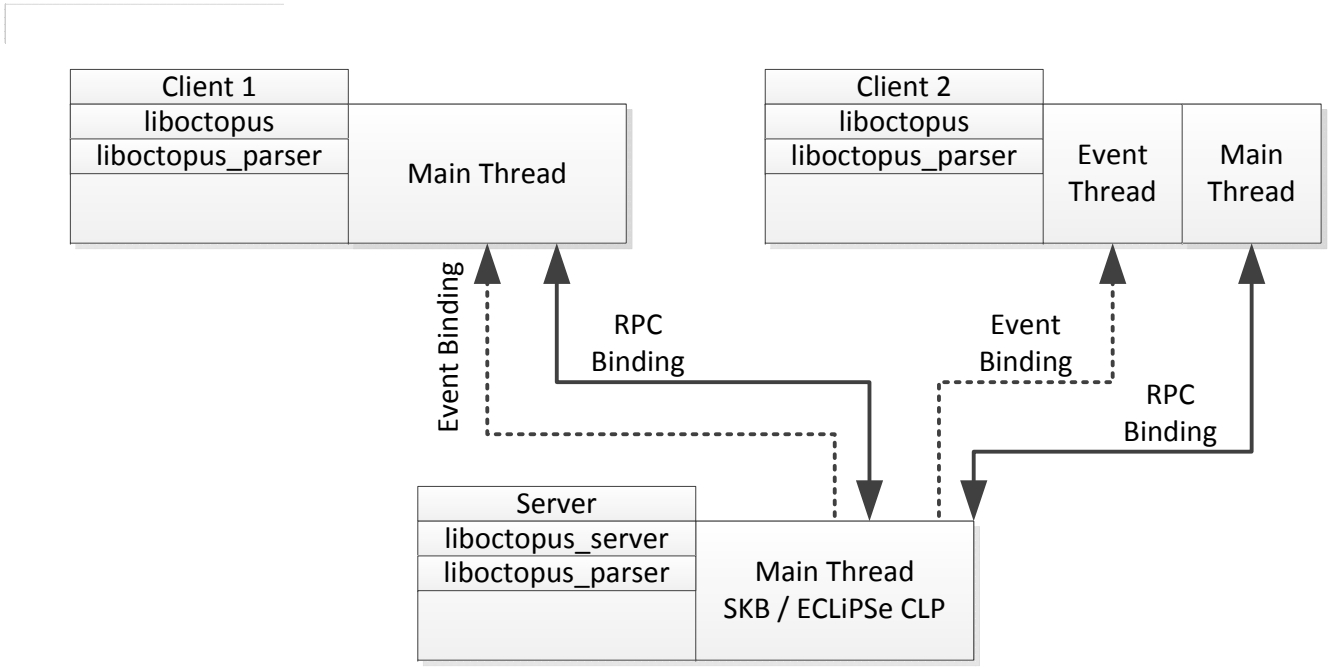
# Our approach in Barrelfish: Octopus

- Searchable key–value store with event triggers
- Publish–subscribe system
- Synchronization primitives

# Requirements

1. OS bootup coordination
   → self-contained
2. Information providers and consumers often independent
   → loosely coupled asynchronous interface
3. Query interface should not block client
   → non-blocking event mechanism
4. Reduce code complexity for programmer
   → high-level interface

# Octopus architecture




- Client–server architecture
- Event binding for asynchronous events
- RPC binding for bidirectional, synchronous communication

# Records and record queries

- Records
  - Unit of storage for the key–value store
  - Unit of transfer for the publish–subscribe system

```
memserver { iref: 20 }

hw.pci.device.1 { bus: 0, device: 1, function: 0,
vendor: 0x8086, device_id: 0x107d, class: 'C' }
```

- Record queries
  - Adds compare operators, regular expressions and variables
  - Used for key–value store and publish–subscribe

```
hw.pci.bridge { bus: 0, acpi_node >= 0,  function: _ }

r'hw\.pci\.device\.[0-9]+' { bus == 0,  class: r'C|X|A' }
```

# Sequential records and triggers

- Sequential record
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- Sequential record
  - Record with automatically appended increasing number
  - Record name passed by application
- Triggers
  - Triggers notify about future changes of the key–value store
  - Installable for *add* and *delete record* or both
  - One-time triggers and continuous triggers

# Implementation

- Octopus is based on ECL$^i$PS$^e$ CLP
  - Prolog + constraint extensions
- Records and queries translated to ECL$^i$PS$^e$ CLP terms
  - Flex and Bison
- ECL$^i$PS$^e$'s backtracking takes care of searching record entries
- Result sent back to client

# Use cases

- Distributed synchronization primitives
  - Locks
  - Barriers
  - Semaphores
- Kaluga device manager based on Octopus triggers

# Use case: locks

- Clients agree on a lock name

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- Acquire lock
  - Every client adds a sequential record
  - If the client has the lowest sequence number, it holds the lock
  - Otherwise it installs a delete trigger on the record with the previous sequence number

# Use case: locks

- Clients agree on a lock name
- Acquire lock
  - Every client adds a sequential record
  - If the client has the lowest sequence number, it holds the lock
  - Otherwise it installs a delete trigger on the record with the previous sequence number
- Release lock
  - Delete own sequential record
  - This triggers the next waiting client

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- Approach
  - Kaluga installs trigger for all new hardware records
  - Discovery code adds records for each device found
  - Kaluga gets notified for each new device
    - Considers HW ID → driver binary mapping
    - Starts driver

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- Example
  - PCIe bus driver finds USB host controller
  - Kaluga starts USB host controller driver
  - USB host controller driver finds specific USB devices
  - Kaluga gets notified and starts USB drivers

# Evaluation

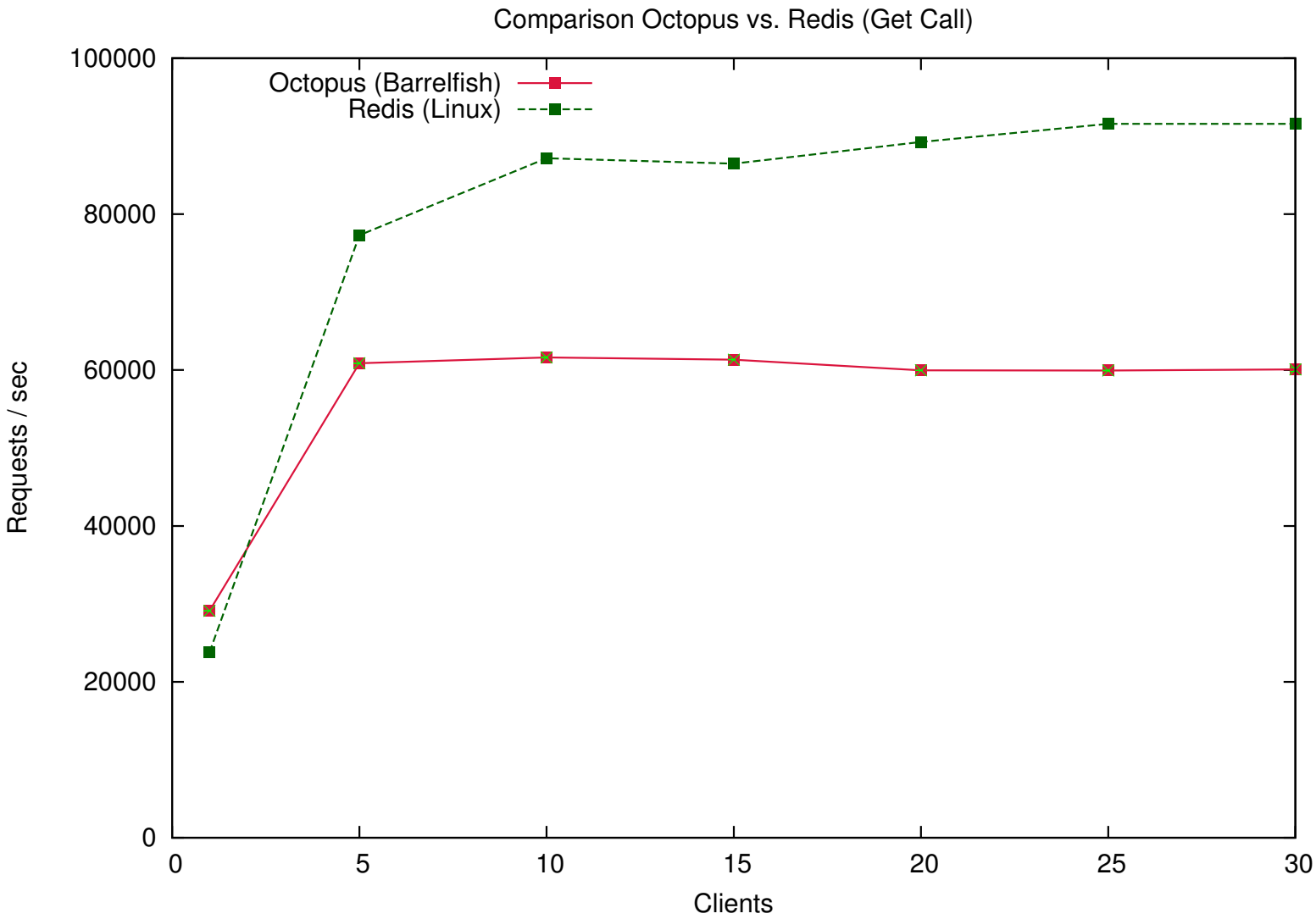
- We care about
  - Octopus should be a clean coordination framework
  - Small code complexity for programmers
  - Reasonable performance

# Evaluation

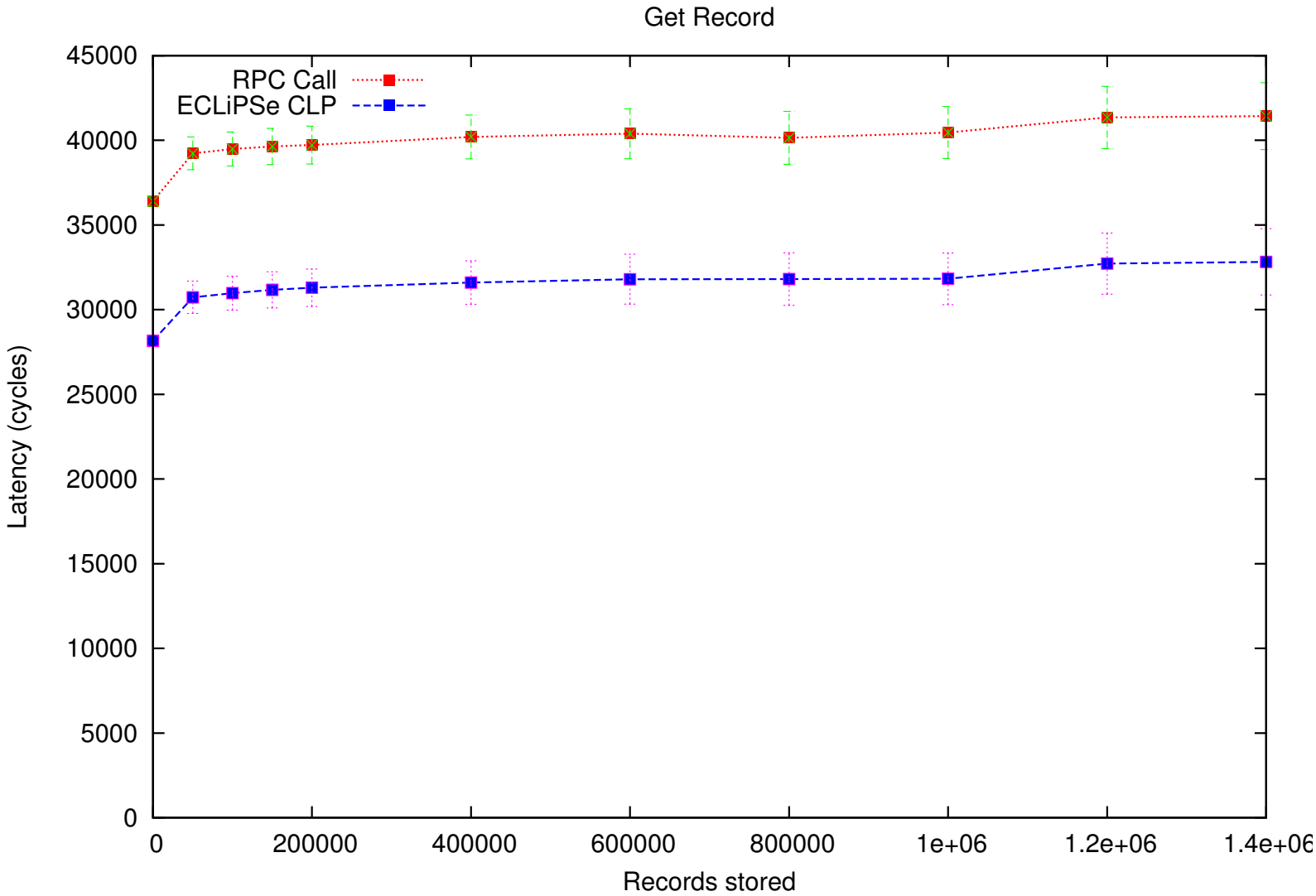
Table: Lines of code

| Functionality | C | Prolog | Flex | Bison |
|---|---|---|---|---|
| Octopus | 3188 | 355 | 150 | 94 |
| Barriers | 102 | | | |
| Locks | 87 | | | |
| Semaphores | 106 | | | |
| Kaluga | 759 | | | |

# Evaluation


Comparison Octopus vs. Redis (Get Call)
Octopus (Barrelfish)
Redis (Linux)
Requests / sec
Clients
100000
80000
60000
40000
20000
0
0
5
10
15
20
25
30

# Evaluation


Get Record
RPC Call
ECLiPSe CLP
Latency (cycles)
Records stored
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0
200000
400000
600000
800000
1e+06
1.2e+06
1.4e+06

# Conclusion

- OSs with distributed structure face distributed systems problems
- Different environment than cluster
- Octopus provides easy-to-use lightweight coordination framework
- Early experiences
  - Distributed synchronization primitives
  - Kaluga device manager

Download:
http://www.barrelfish.org