SynCron

Efficient Synchronization Support for Near-Data-Processing Architectures

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Executive Summary

Problem:

Synchronization support is challenging for NDP systems

Prior schemes are not suitable or efficient for NDP systems

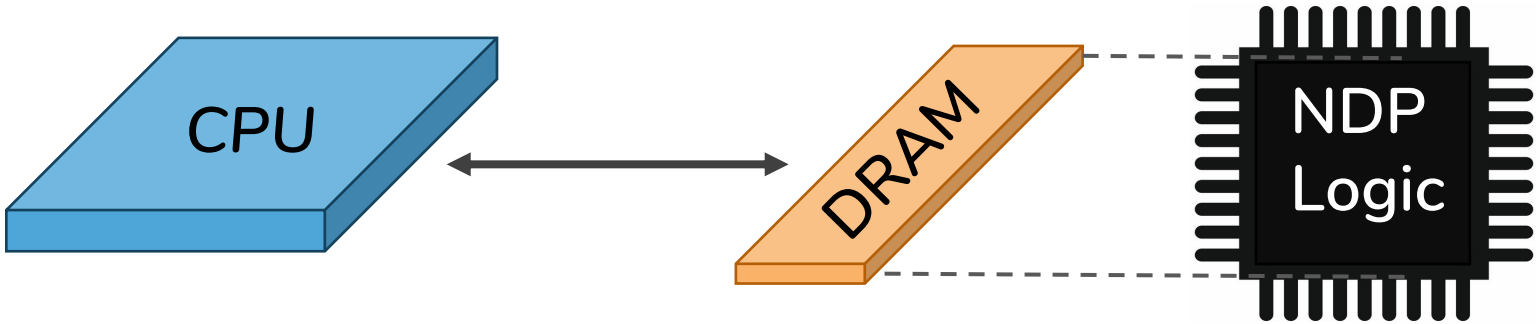
Contribution:

SynCron: the first end-to-end synchronization solution for NDP architectures

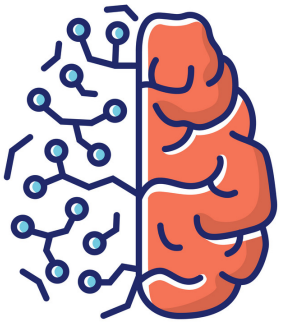
Key Results:

SynCron comes within 9.5% and 6.2% of performance and energy of an Ideal zero-overhead synchronization scheme

Near-Data-Processing (NDP) Systems

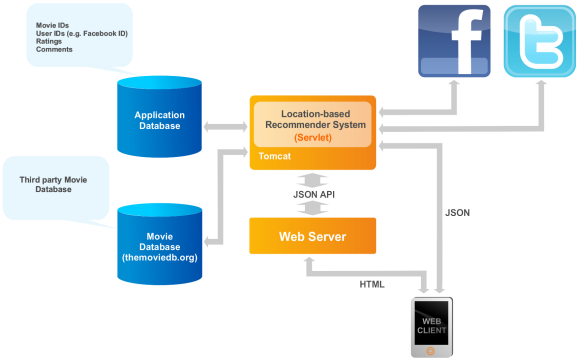


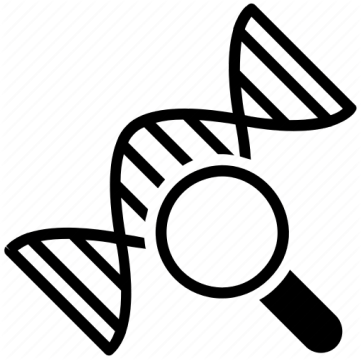
Graph Analytics



Neural Networks

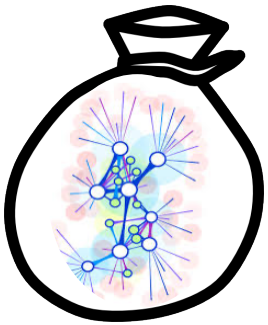
Recommendation Systems





Bioinformatics

Synchronization is Necessary

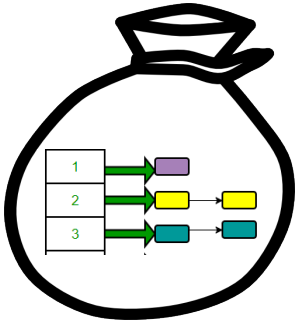


Graph Analytics

Bioinformatics

Databases

Image Processing



Concurrent Data Structures

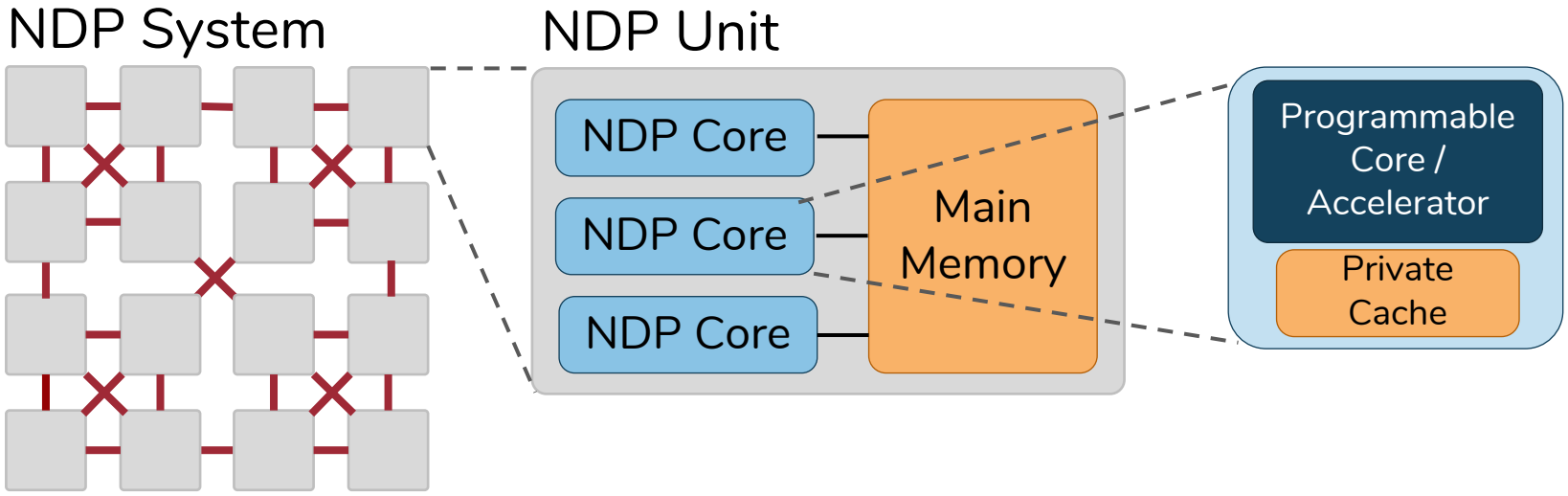
Single Source Shortest Path (SSSP)

Locks

Barriers

```
for v in Graph:
    for u in neighbors[v]:
        if distance[v] + edge_weight[v, u] < distance[u]
            lock_acquire(u)
            if distance[v] + edge_weight[v, u] < distance[u]
                distance[u] = distance[v] + edge_weight[v, u]
            lock_release(u)
```

Baseline NDP Architecture



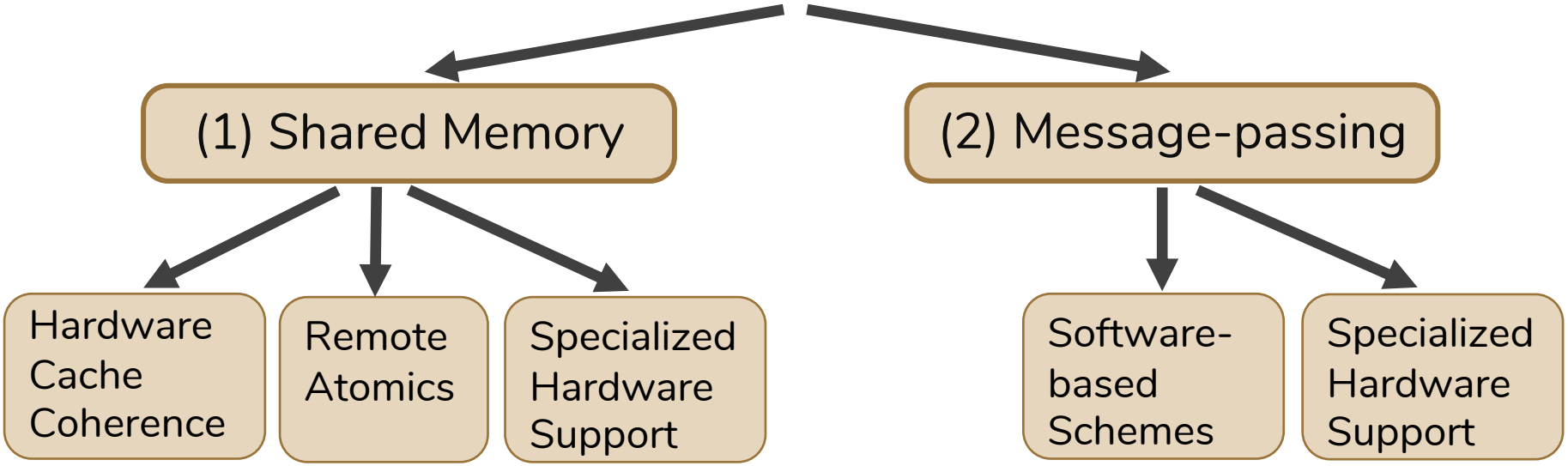
Synchronization challenges in NDP systems:

(1) Lack of hardware cache coherence support

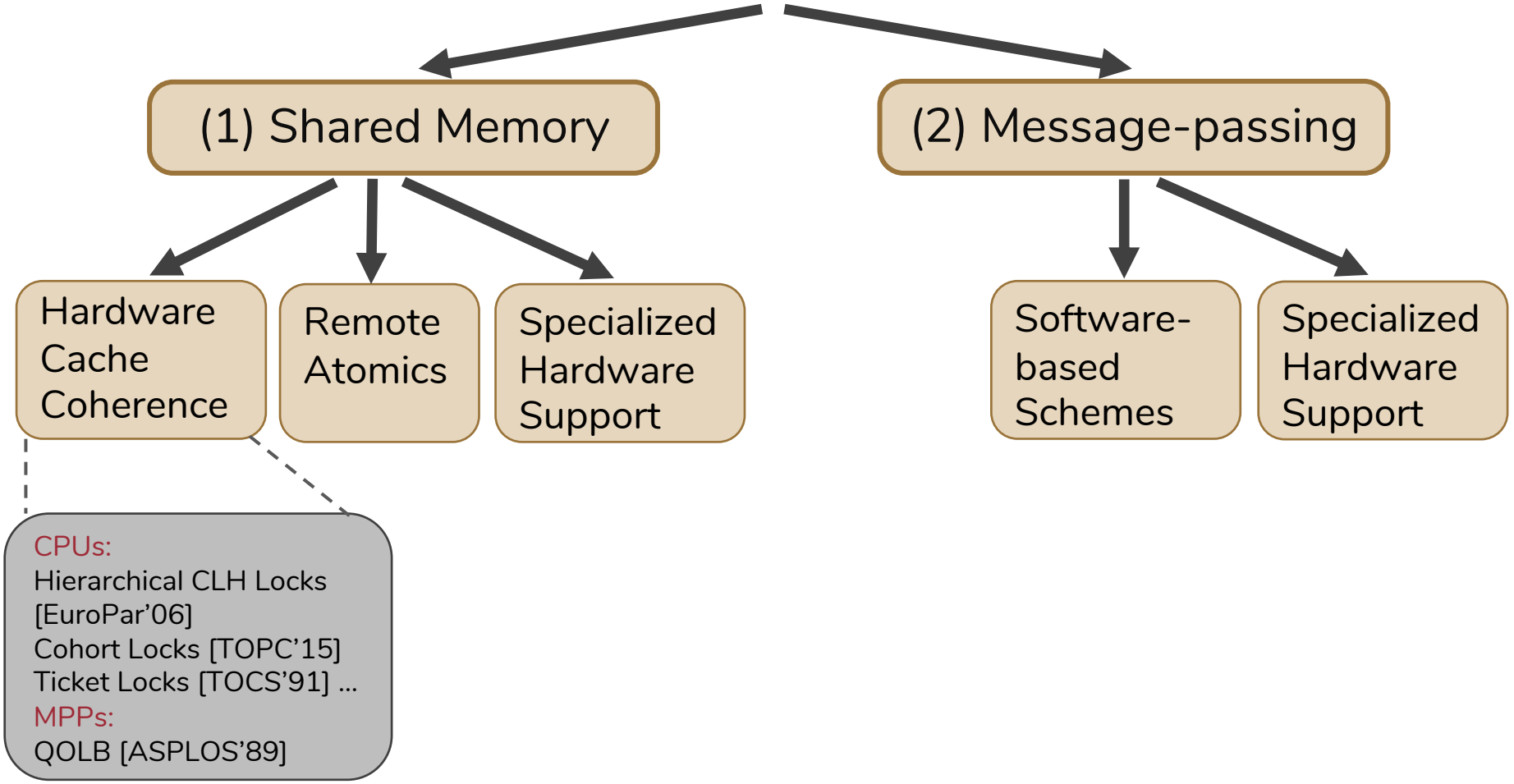
(2) Expensive communication across NDP units

(3) Lack of a shared level of cache memory

NDP Synchronization Solution Space

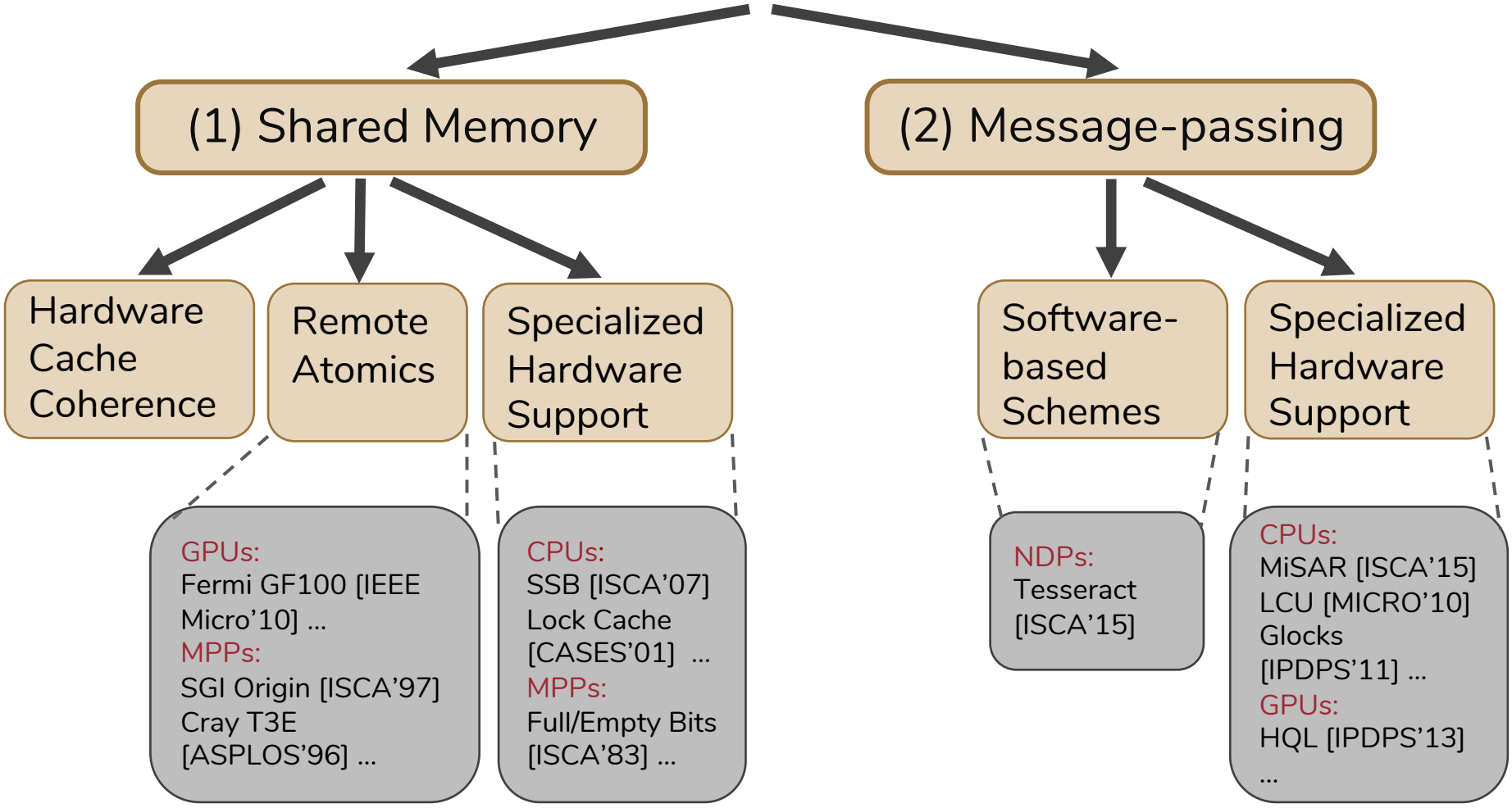


NDP Synchronization Solution Space



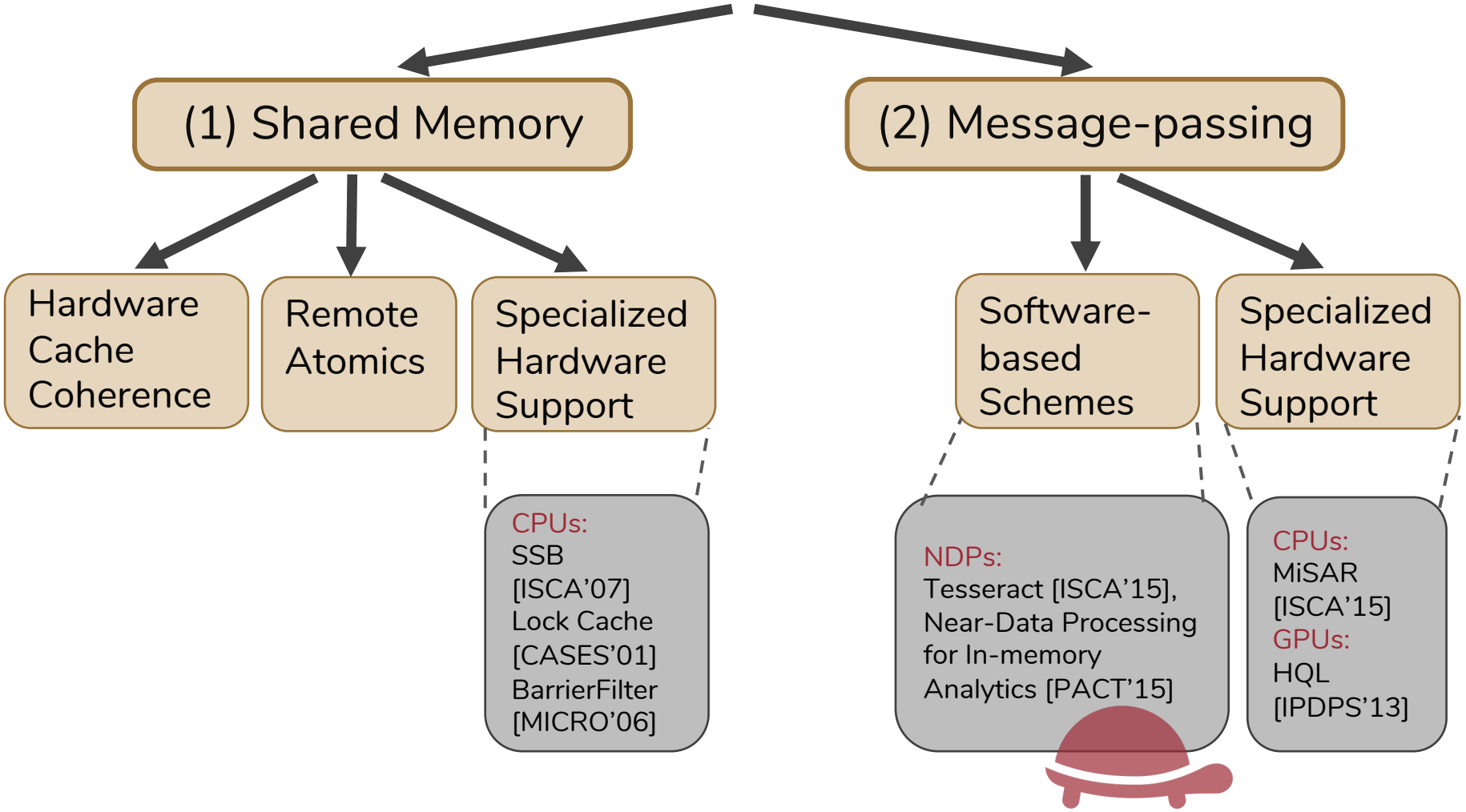
Lack of hardware cache coherence support

NDP Synchronization Solution Space



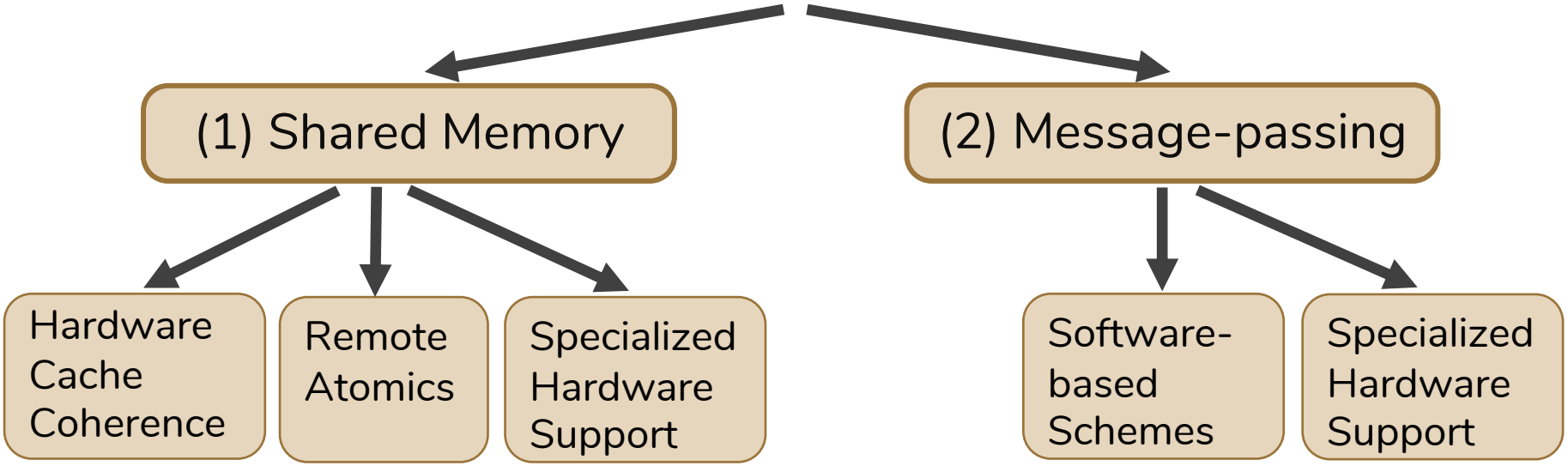
Expensive communication across NDP units

NDP Synchronization Solution Space



Lack of a shared level of cache memory

NDP Synchronization Solution Space



Prior schemes are not suitable or efficient for NDP systems

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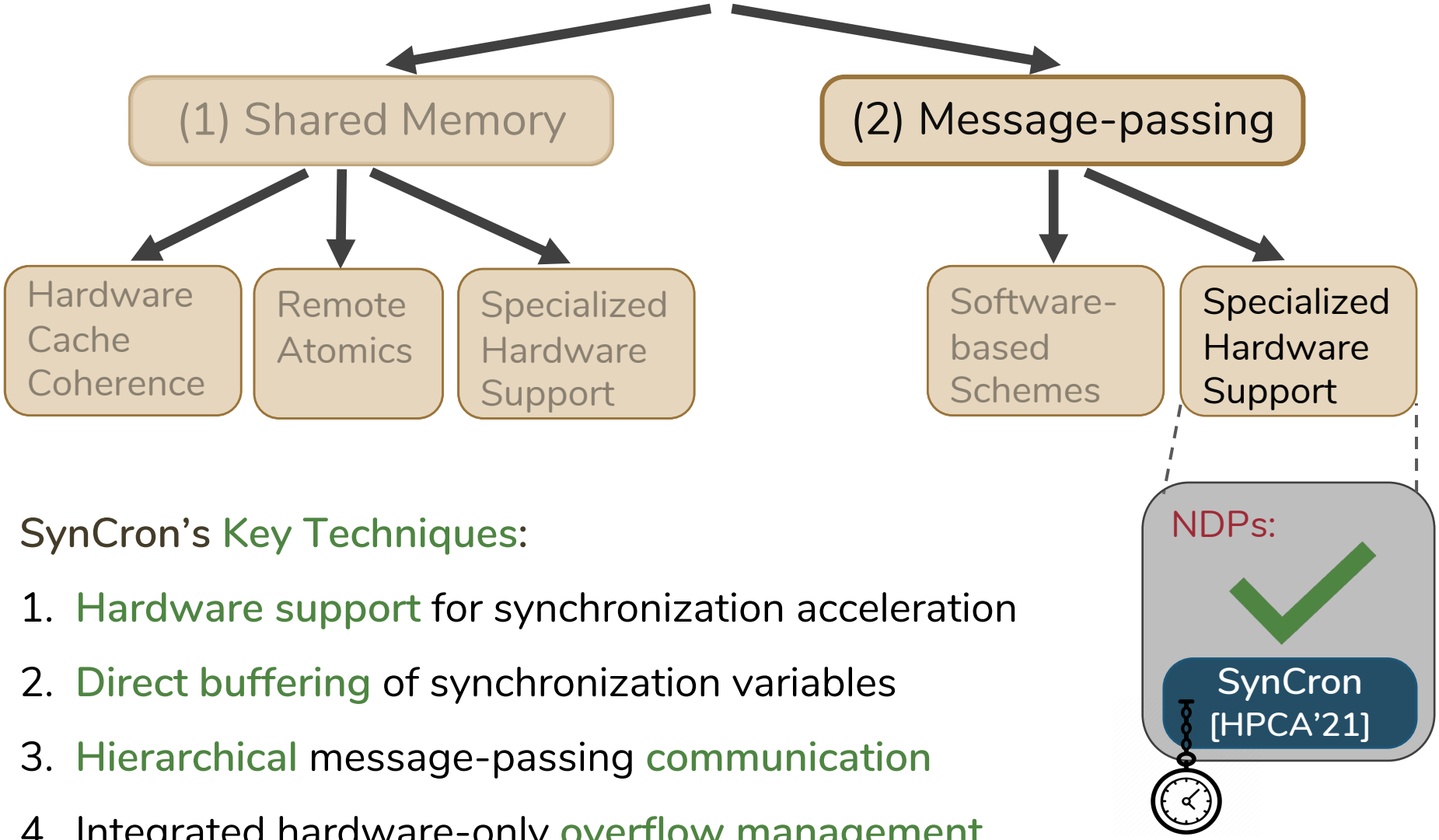
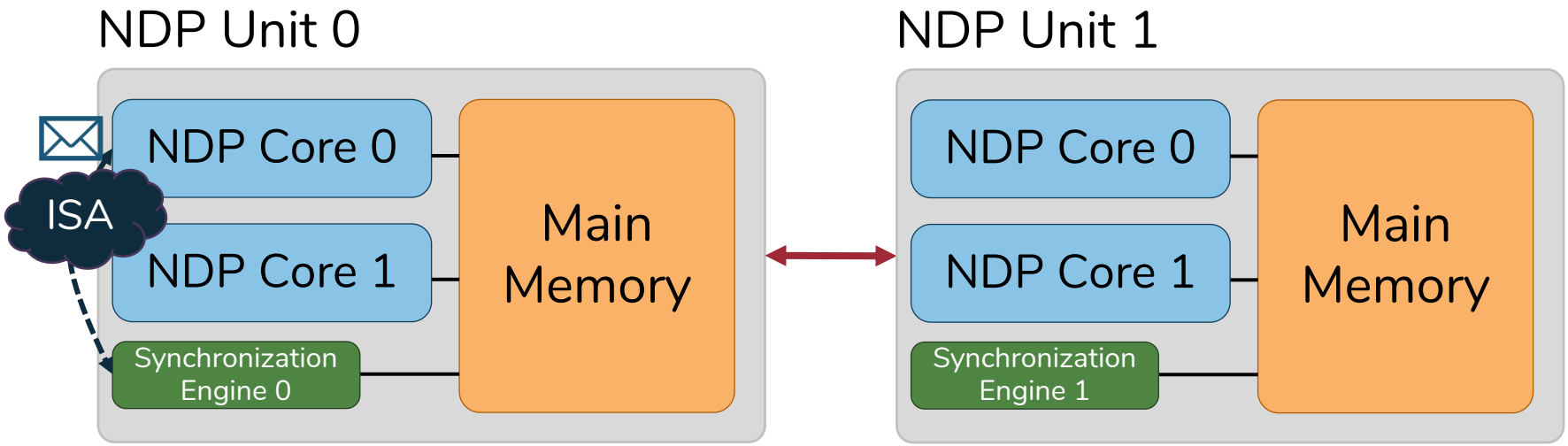


SynCron's Key Techniques:

1. Hardware support for synchronization acceleration
2. Direct buffering of synchronization variables
3. Hierarchical message-passing communication
4. Integrated hardware-only overflow management

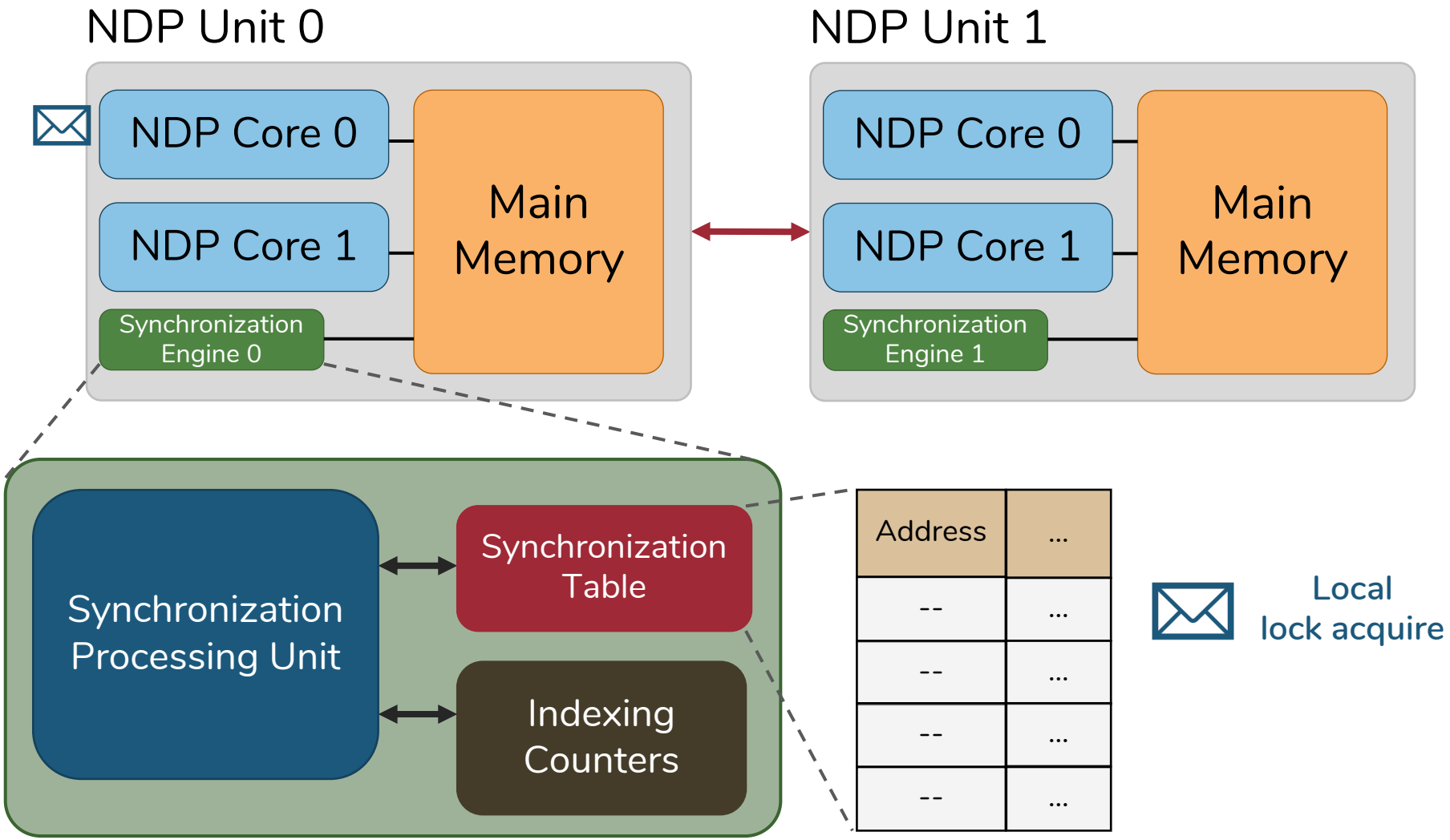
1. Hardware Synchronization Support



Local lock acquire

- ✓ No Complex Cache Coherence Protocols
- ✓ No Expensive Atomic Operations
- ✓ Low Hardware Cost

2. Direct Buffering of Variables



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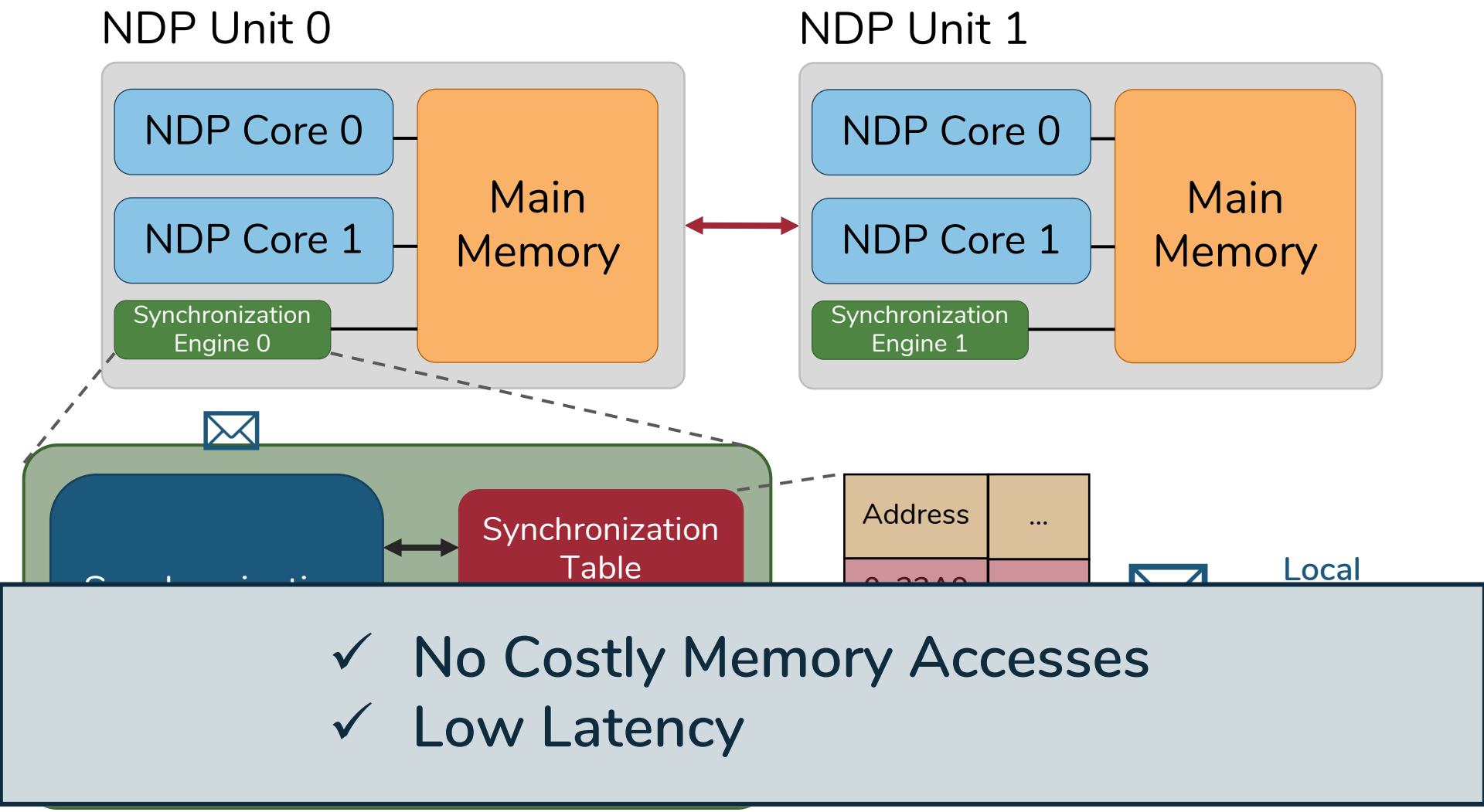
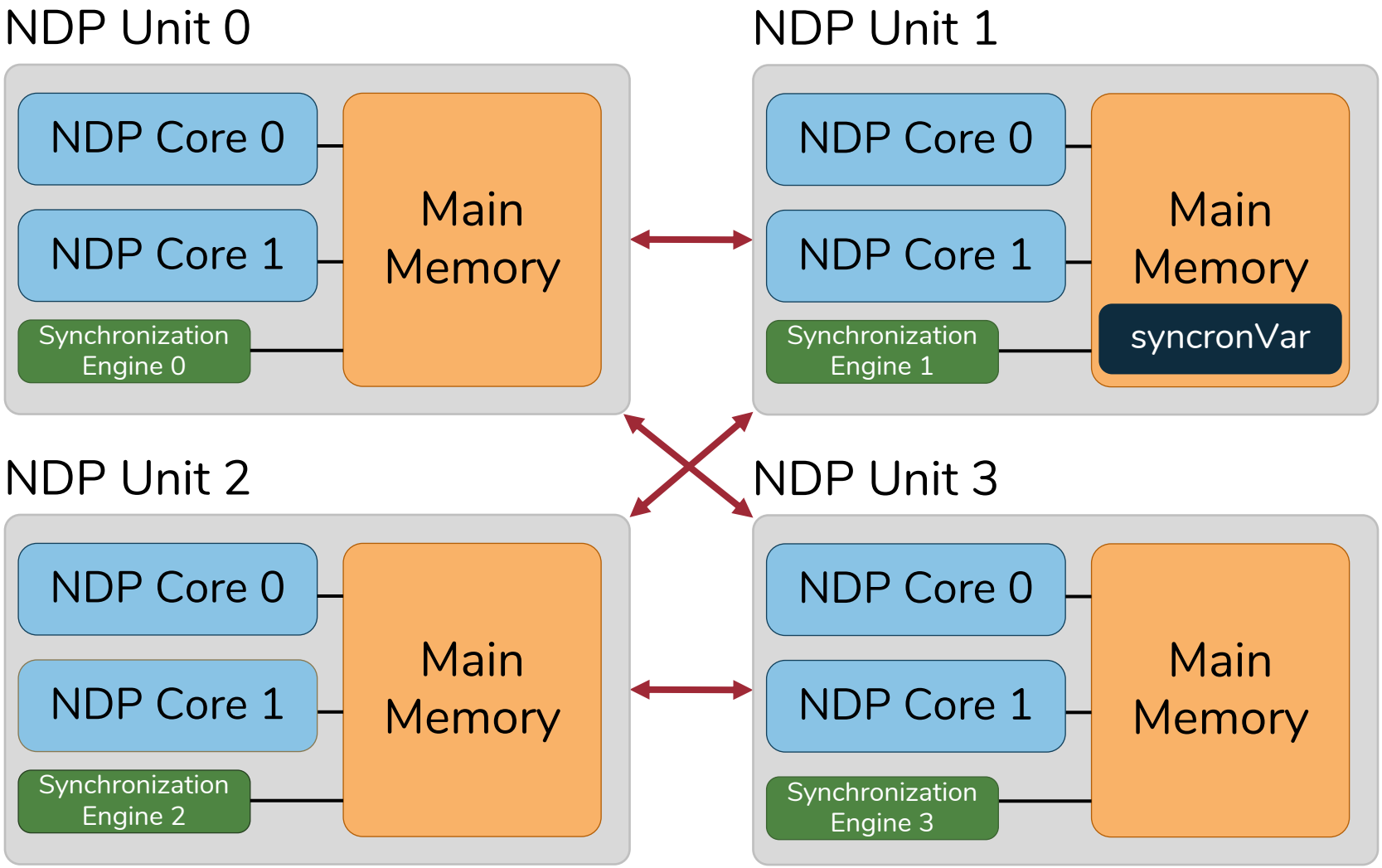


- ✓ No Costly Memory Accesses
- ✓ Low Latency

3. Hierarchical Communication



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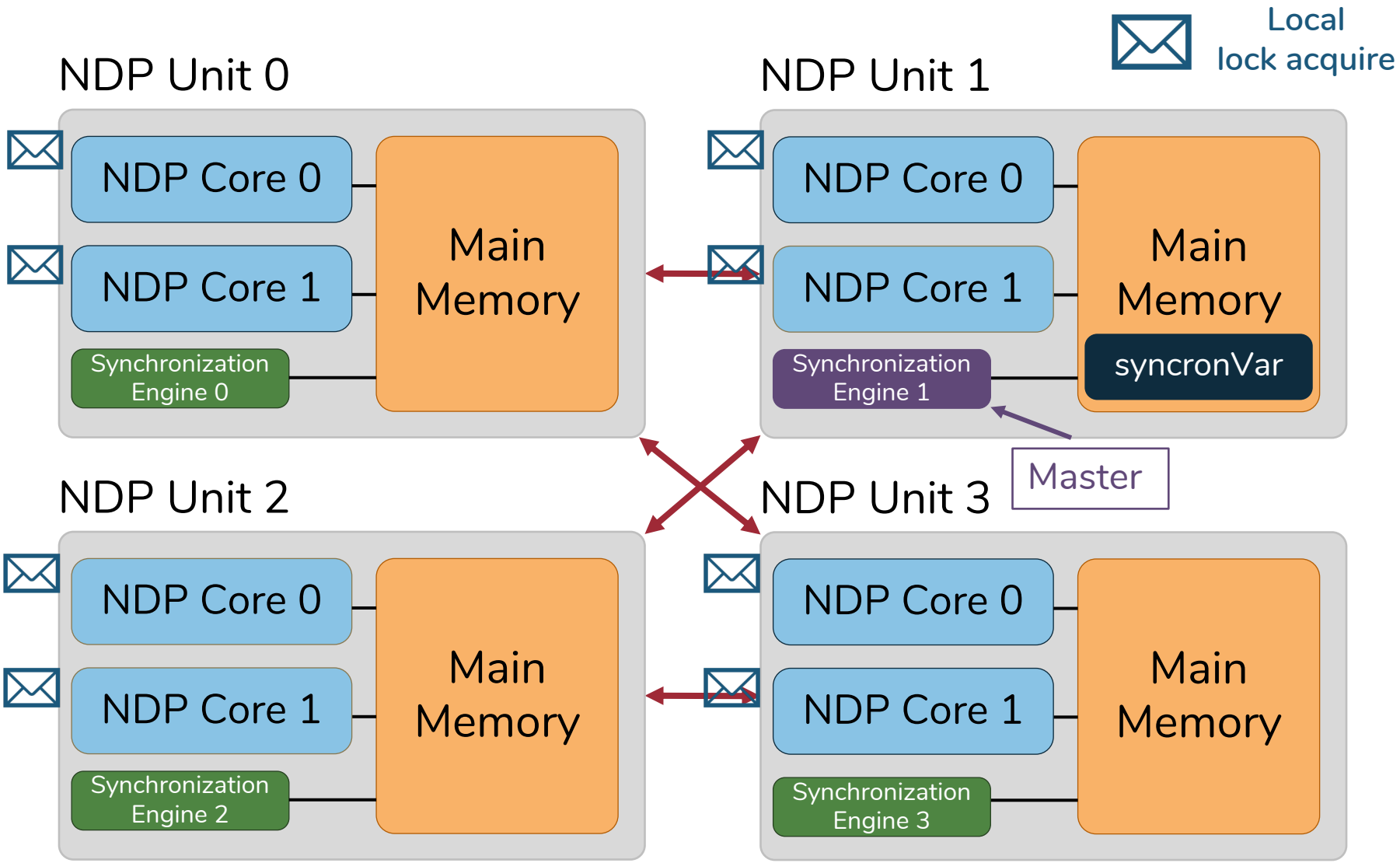

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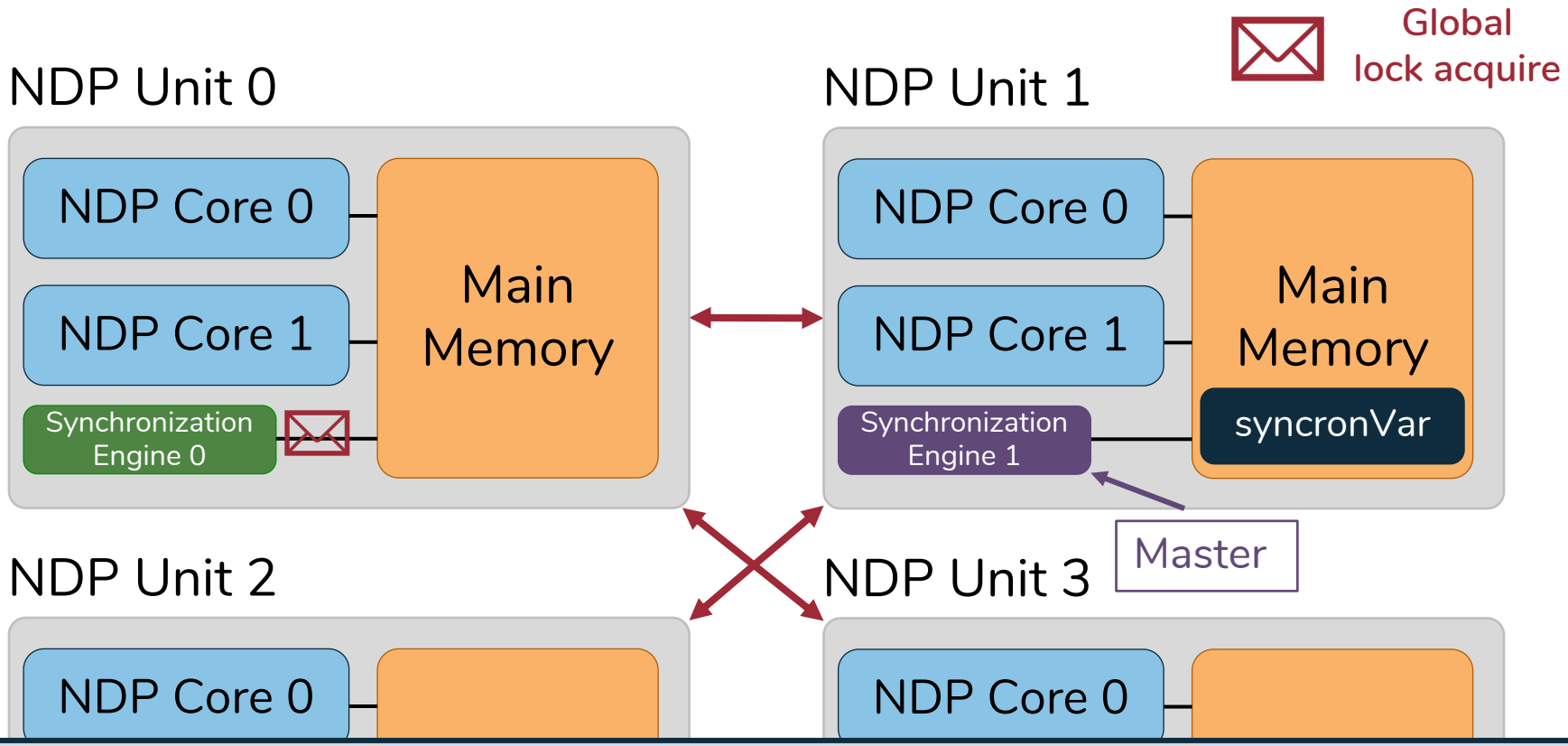
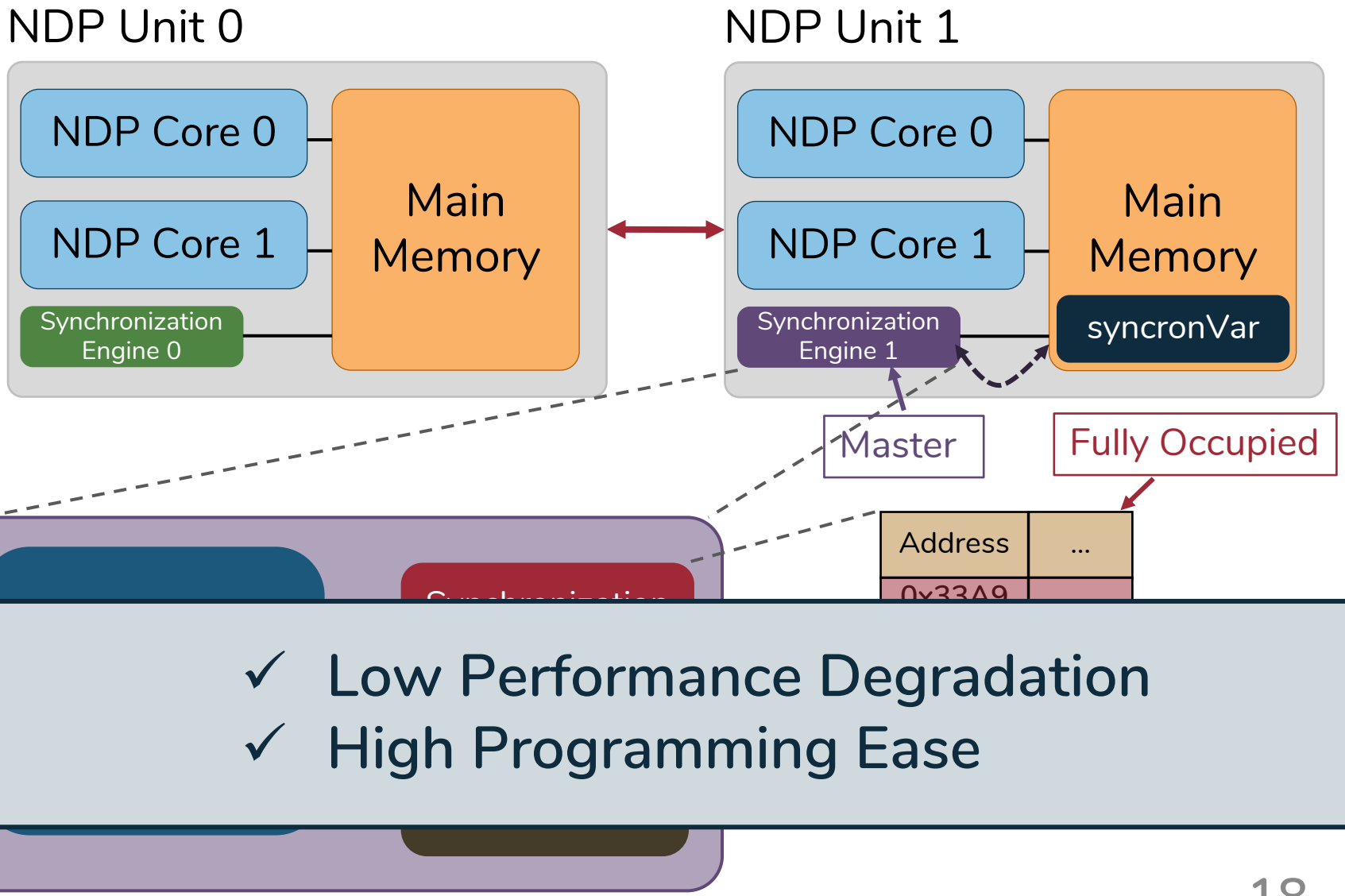


✓ Minimize Expensive Traffic

4. Integrated Overflow Management



- ✓ Low Performance Degradation
- ✓ High Programming Ease

SynCron

The first end-to-end synchronization solution for NDP architectures

SynCron's Benefits:

1. High System Performance
2. Low Hardware Cost

SynCron comes within 9.5% and 6.2% of performance and energy of Ideal zero-overhead synchronization

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