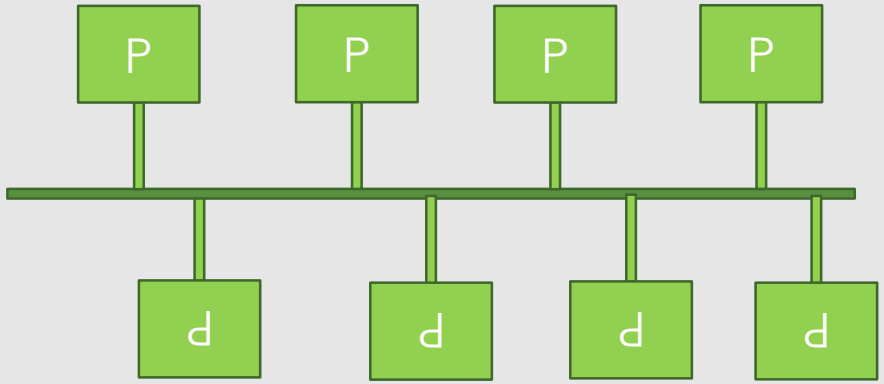
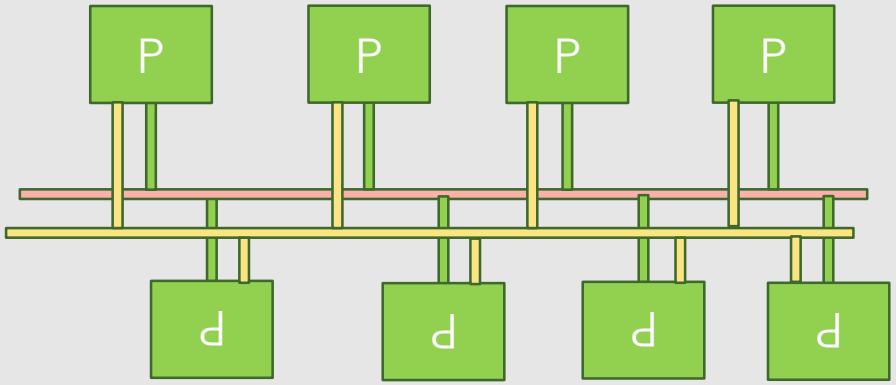
LECTURE 29: LIMITATION OF SMP, SCALABLE CACHE COHERENCE PROTOCOL

Symmetric Multiprocessors (SMPs)Limitations

- Bus does scale
  - per core bandwidth decreases as more nodes are added
  - latency increases with length

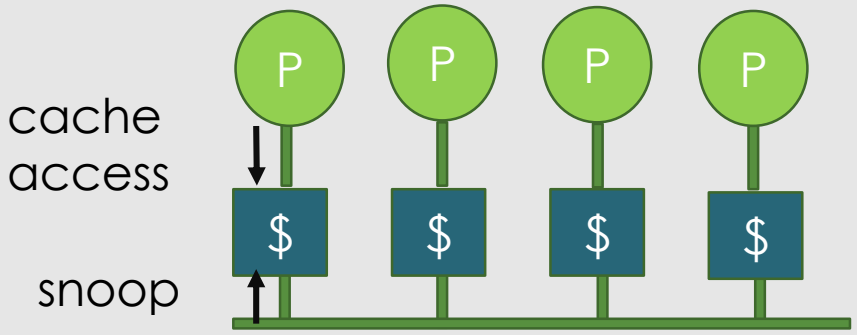


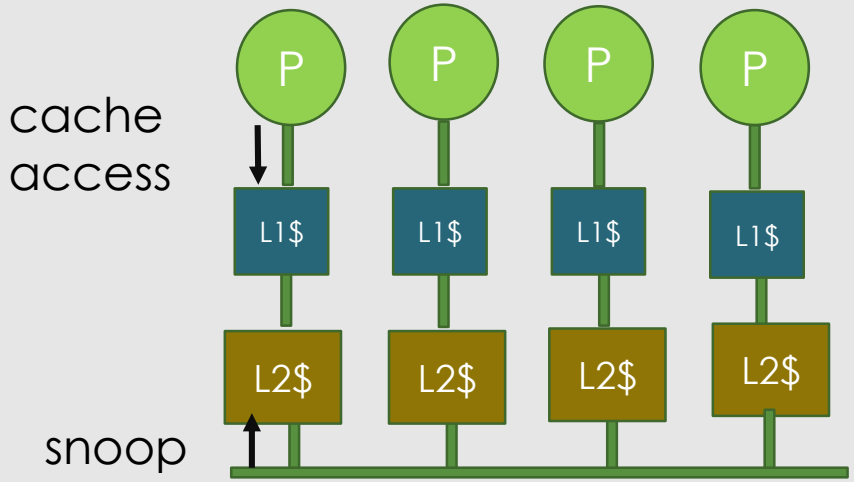
- Solution
  - use multiple buses
  - crossbar
  - small point-to-point network
- SMP with 4-8 cores feasibility



SMP Limitations

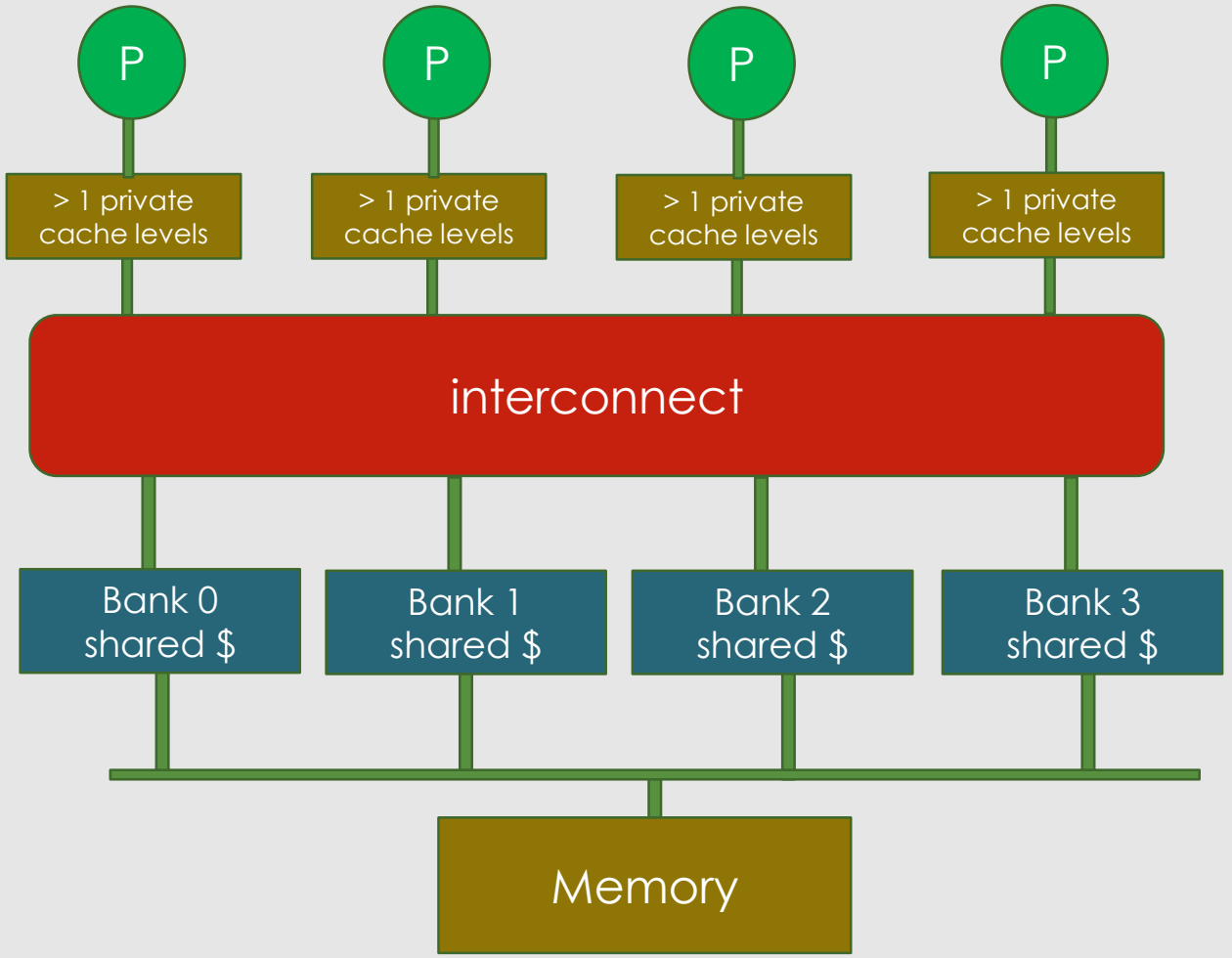
- Each bus transaction must check tags
- Could interfere with processor cache access
- Solutions
  - duplicate tags; snoop in duplicate tags
  - > 1 private $ levels
    - processor accesses L1
    - snoop in L2
    - inclusion





SMP Limitations

- How to increase memory bandwidth?
- Multi-banked shared + high speed interconnect between LL private caches and multi-banked shared cache

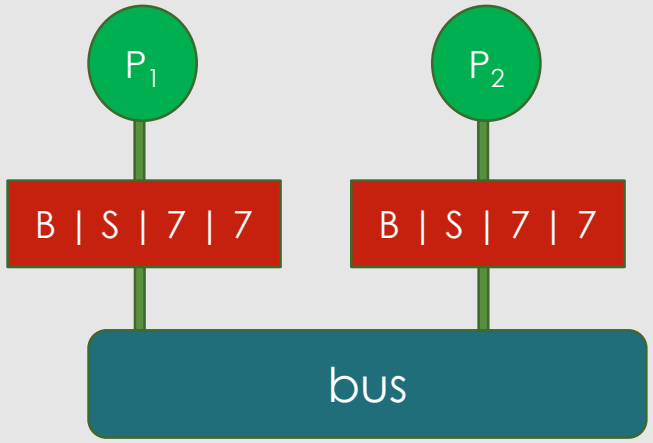


Implementing Cache coherence

- Write misses and invalidate are not atomic
- P1 and P2 simultaneously issue invalidates to block B present in both caches

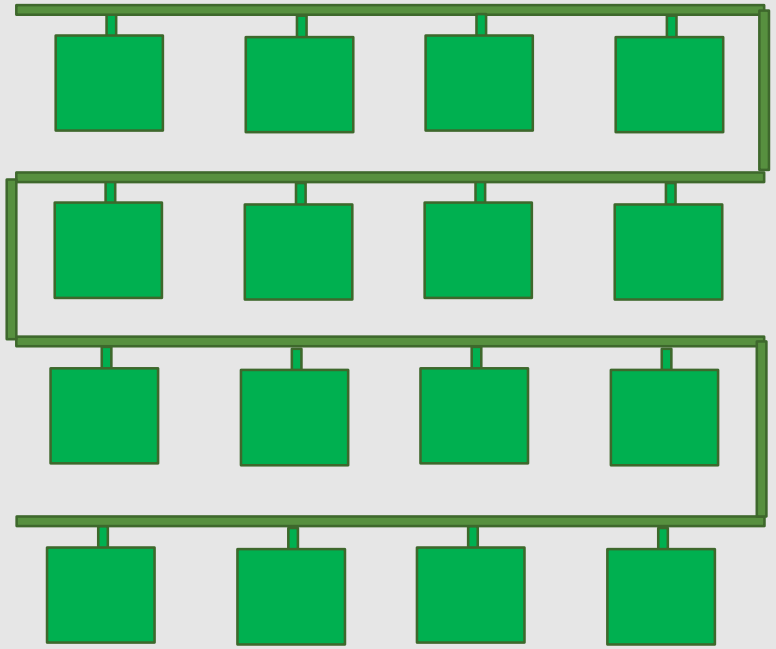
PrWr B[0]= 8

PrWr B[1]= 9



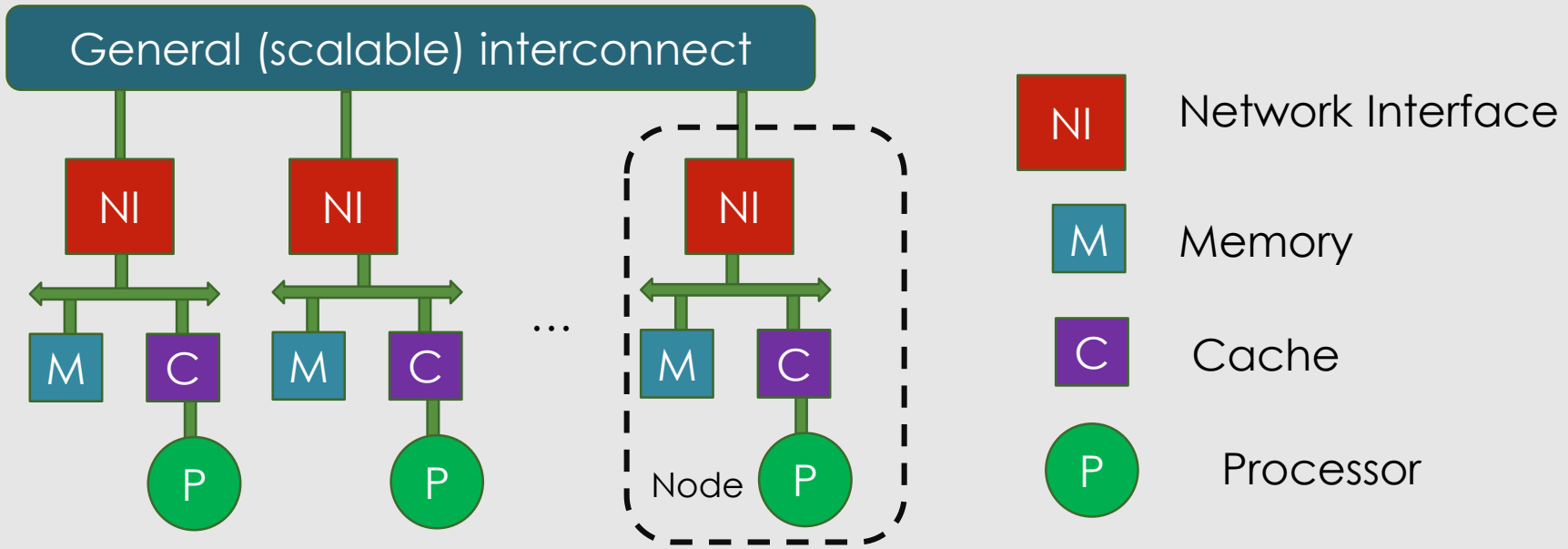
Limitations of Snooping Protocols

- Snooping cache coherence relies on broadcast
  - Requires communication with all caches on every cache misses
- Bus does not scale
- When adding cores
  - length-> latency increases
  - per core bandwidth decreases



Increasing Bandwidth

- Replace bus by scalable interconnect
- Distribute memory across nodes
  - local access faster than remote access
  - cc-NUMA architecture



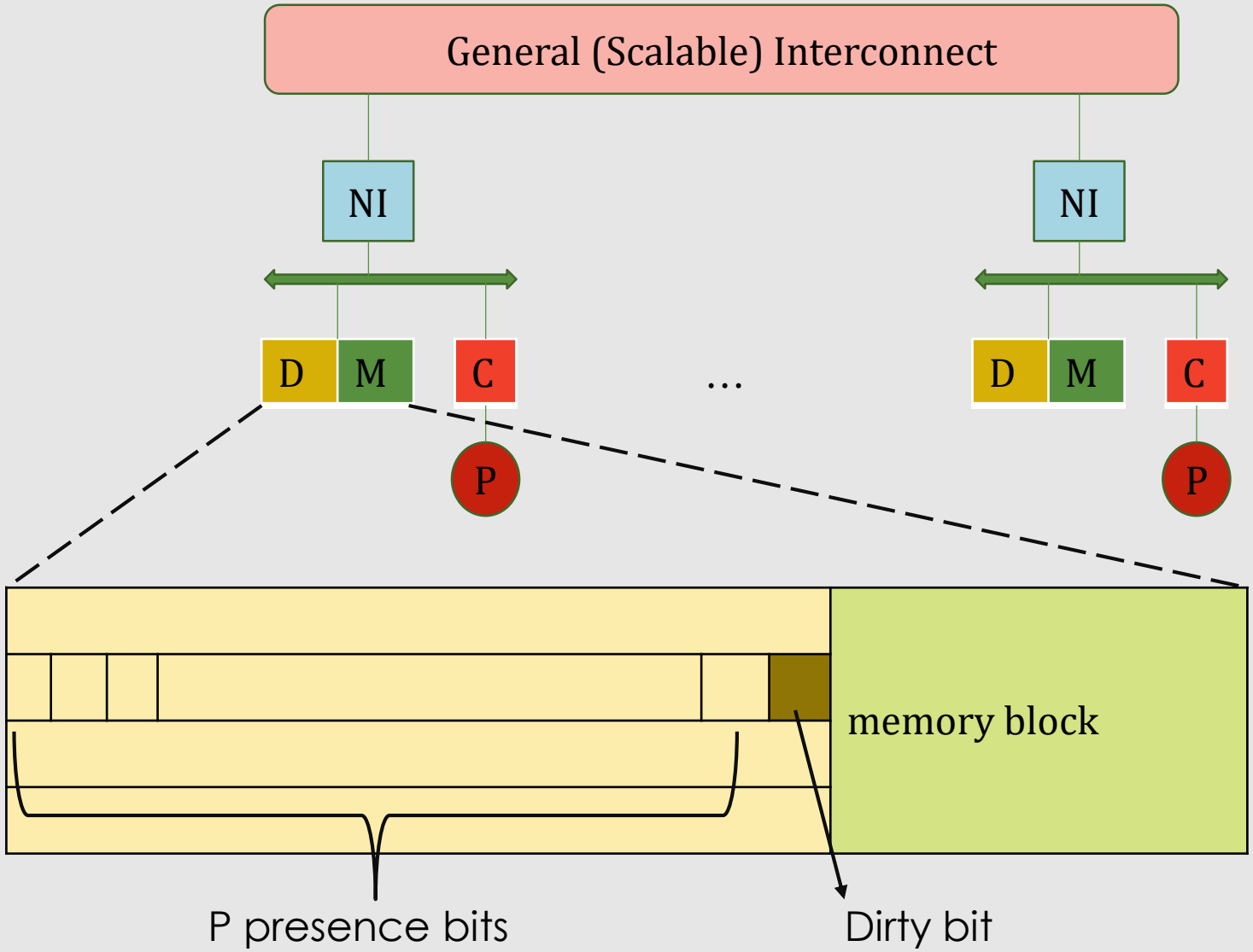
Scalable Cache Coherence

- Distributing memory gains little if every cache miss still requires broadcast
- Solution: Directory protocol
- Directory keeps track of the state of every block
  - which cache have copies
  - if it is dirty/modified

directory entry for B

Node 1 and Node 3 has a copy of this block, while Node 0, 2 and 4 does not have

Basic Full Directory Protocol

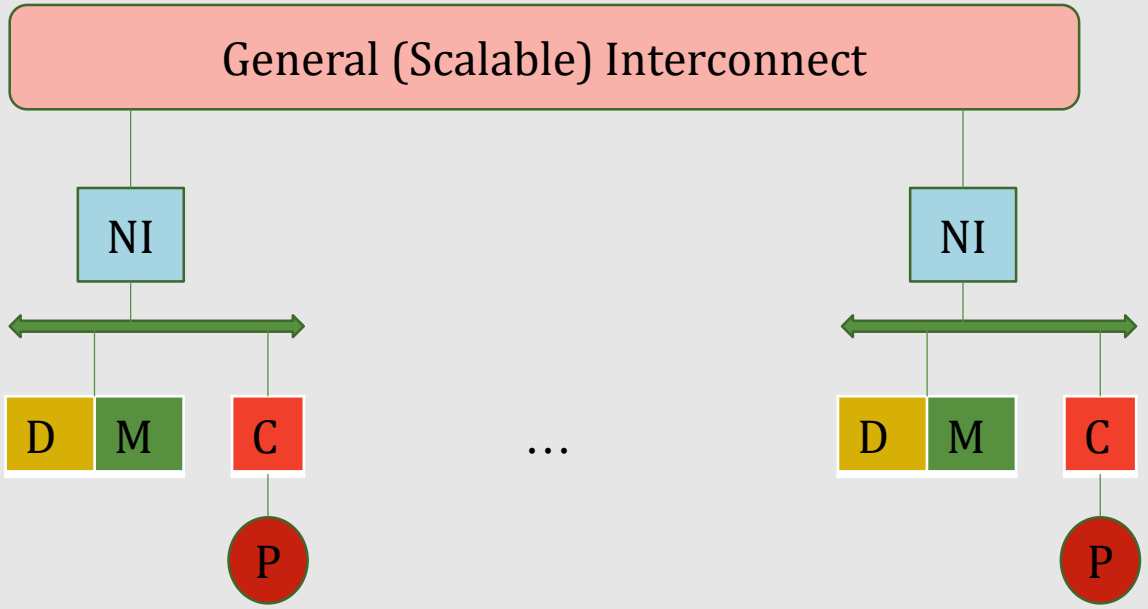


D Directory

- p[i]= processor i has a copy
- d=1 -> copy is dirty/modified
  - only 1 p[i] set

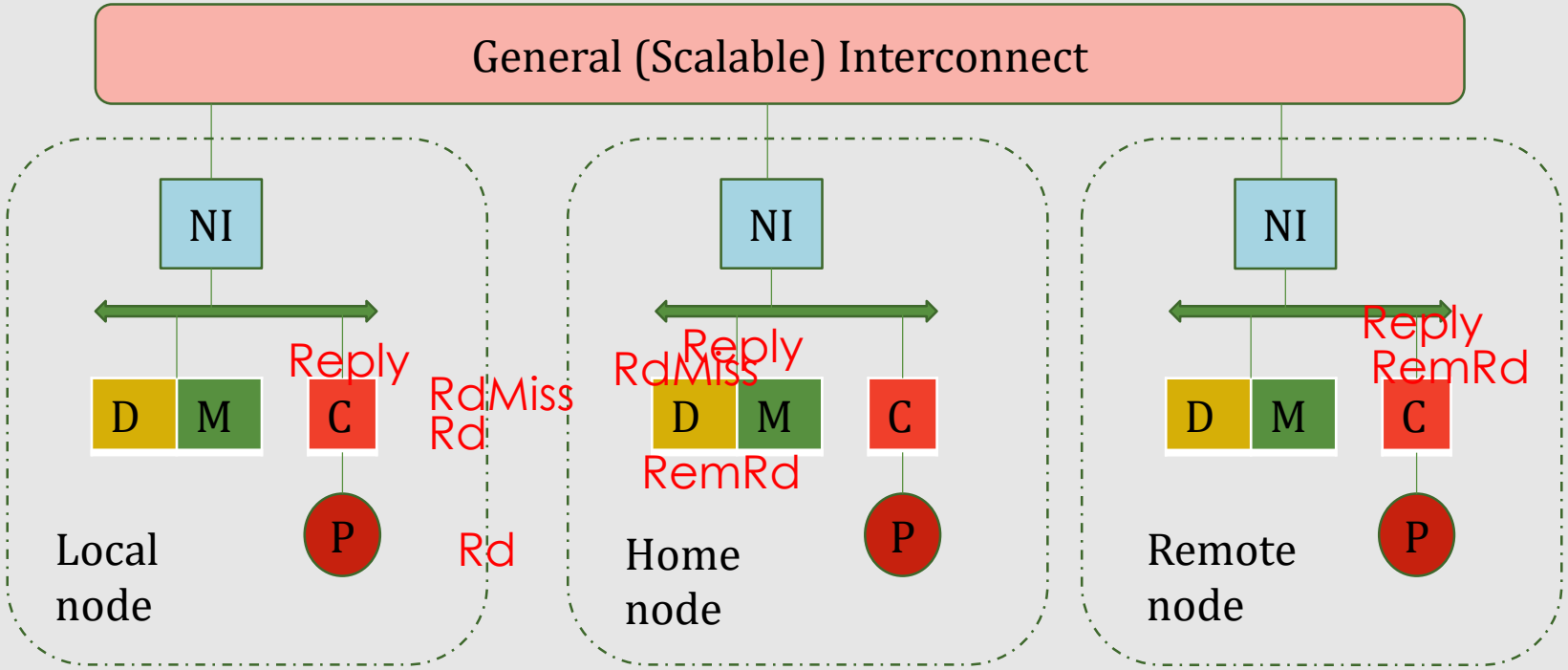
Distributed Directory – Home Node

- Directory is distributed along with memory
- Node I contains directory entries for memory blocks mapped onto its part of physical shared memory
  - Home node of those blocks
  - Home node ID can be found during virtual to physical address translation



Full Directory Protocols – Types of Nodes

- 3 types of nodes
  - local/requesting nodes: node that makes request
  - home node: node where memory block (and directory entry) resides
  - remote node: node(s) that contain(s) copy of block
- Example-Read miss to block dirty at remote node



Thank You