Multi-processor

Snoopy protocol （总线监听协议）

目的

解决 多处理器中 cache 的 一致性 (**cache coherence & consistency**)

- coherence : 不同 cache 的同一个数据不同
- consistency : cache 与 memory 的数据不同

特点

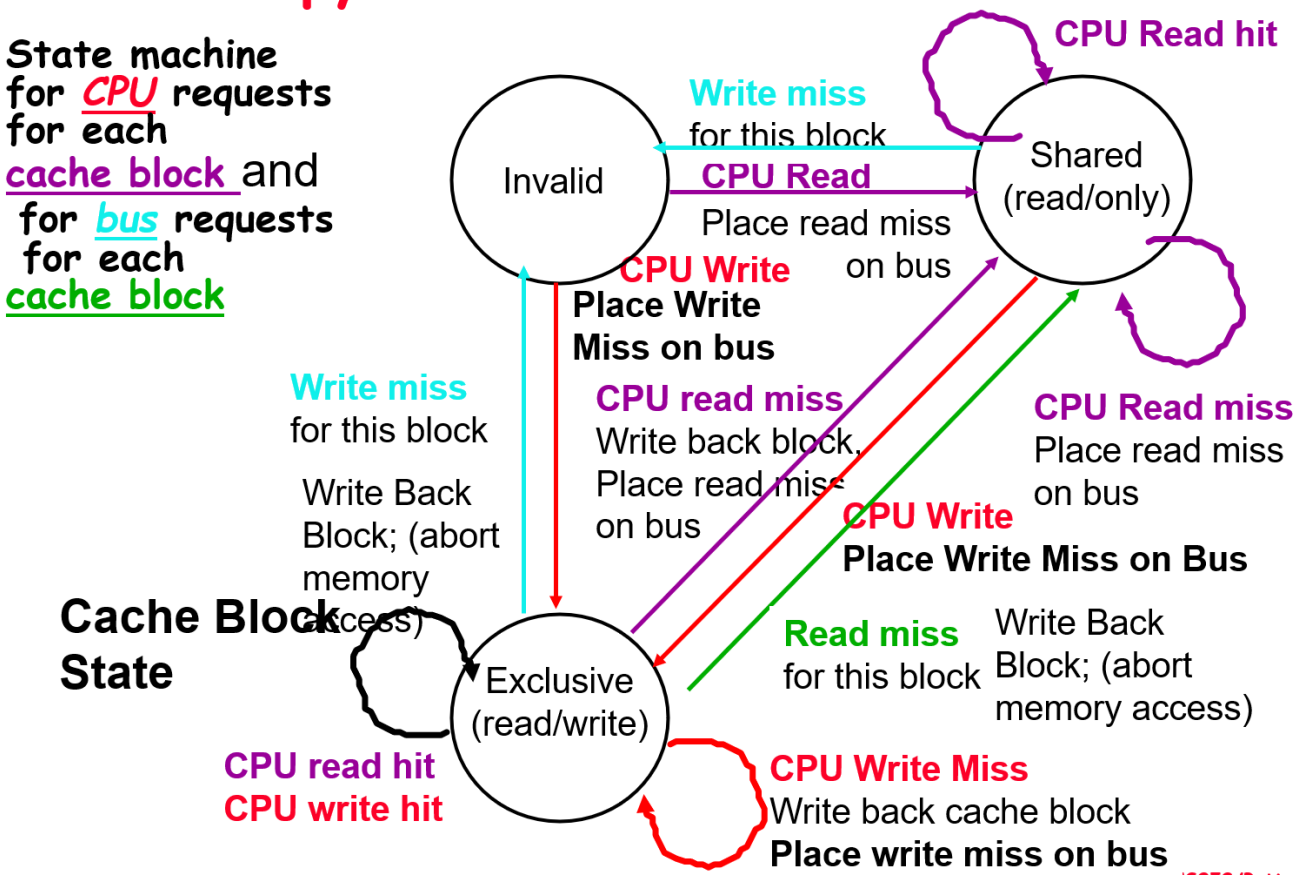
- Send all requests for data to all processors
- Processors snoop to see if they have a copy and respond accordingly
- Requires **broadcast**, since caching information is at processors
- Works well with **bus** (natural broadcast medium)
- Dominates for **small scale** machines (most of the market)
- 分布式，与之相对的是 directory-based schemes （集中式）

类型

Basic Snoopy Protocols

- **Write Invalidate Protocol:**
  - **Multiple readers, single writer**
  - **Write to shared data: an invalidate is sent to all caches which snoop and *invalidate* any copies**
  - **Read Miss:**
    - » **Write-through: memory is always up-to-date**
    - » **Write-back: snoop in caches to find most recent copy**
- **Write Broadcast Protocol (typically write through):**
  - **Write to shared data: broadcast on bus, processors snoop, and *update* any copies**
  - **Read miss: memory is always up-to-date**
- **Write serialization: bus serializes requests!**
  - **Bus is single point of arbitration**

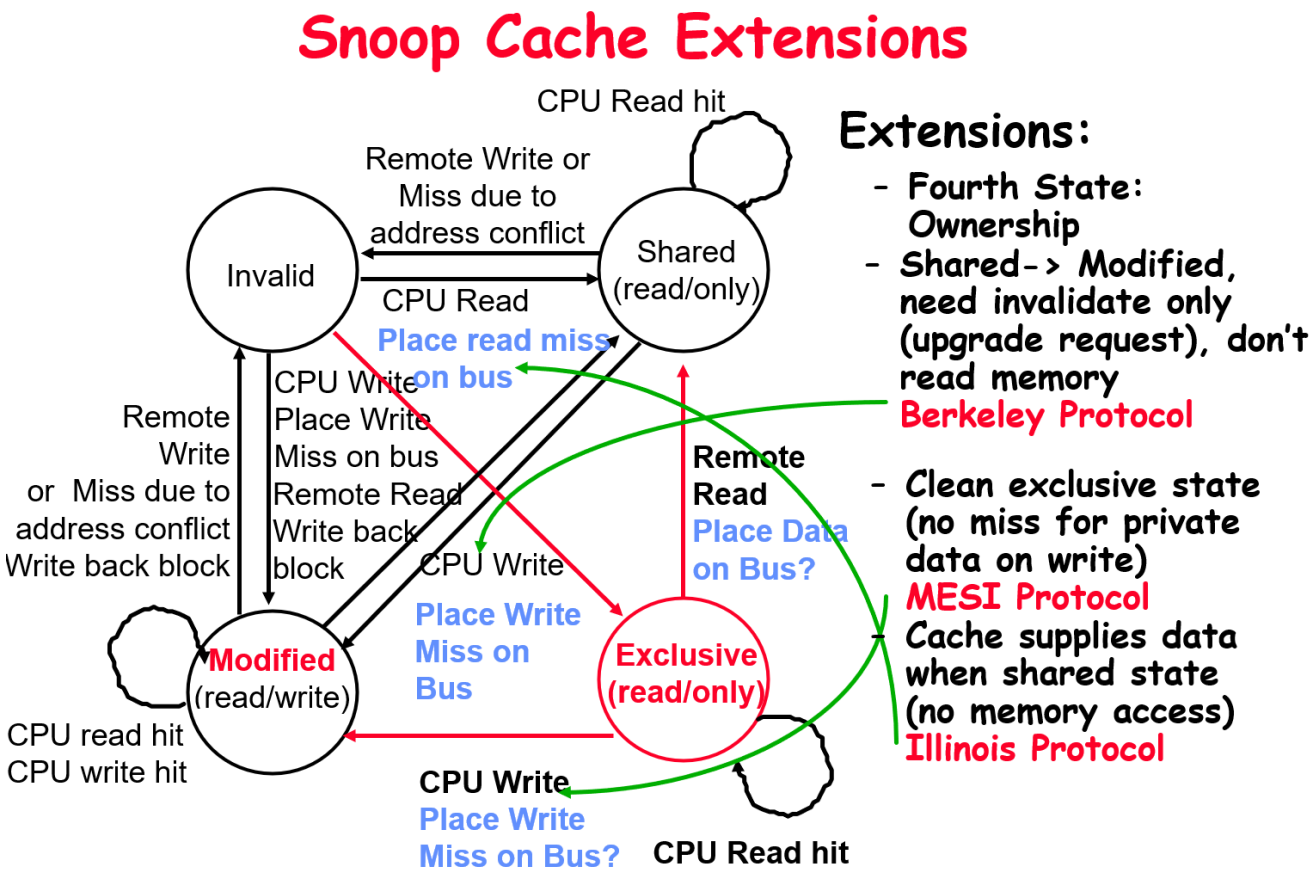
cache的状态机描述



实际上，上图的 `Exclusive` 应该更正为 `Modified`。

Some extensions

实际上就是增加了新的状态。



MESI：

> 有协议MSI `->` 为什么还需要MESI：对于唯一的读写者，让其在 Exclusive 状态下运行，防止到总线上广播信息，影响其他通信。

SMP/Cluster/Cloud

“功能”辨析：

- infrastructure：概念更大，对设计者而言
- utility-computing： 对用户。 multi-cs `->` uni-cs `->` unix
- ubiquitous

Multi-core

New Amdahl's Law

嵌入式：system on chip （SOC）

Dark Silicon

为什么“一核有难，八核围观”?

芯片发热公式：$P = cV^2 f$，V为电压，c为整个系统的容性，取决于线之间的距离。

由于发热，多核的利用率往往就比较低，而且受限于工艺精度。

核并不是越多越好?

Distributed system

Availability VS Reliability

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software pipeline