RW: Multi-Processor

Coherence ✓ vs. Consistency ✓

based on → board LAN Internet

SMP / cluster / Cloud

* Distributed System

* Multi-core { New Amdahl's law / Dennardian law (?)

Infrastructure 基础架构? / Utility ?

1. ESI (MSI) → MESI ?

后面的 "E": 是唯一具有该贝的人

"S": 多个 core 都具有该贝

原因: 若是唯一读者，那么修改无需通知别人 (不在总线上发 sign)

可减少干扰与总线占用

2. Multi-Core

2007 new Amdahl's law

$$T_{old}/T_{new} = \frac{T_s + T_p}{T_s + T_p/s}$$

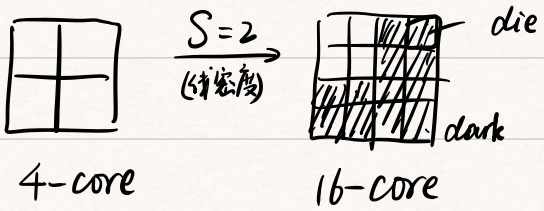
T_p: 可并行部分

s: core count

T_{para} ~ 30% 时. Speedup ≤ 1.41

一个程序内可能可并行较少，但可多个不相干程序 (用前想法)

1974 Dennardian law



$$P = c \cdot V^2 \cdot f \cdot N$$

功率 ↑ 容性 (各种电容等) ↑ 电压 ↑ 频率

但单位面积散热面积有限

4→16 core　　摩尔定律. 18个月 S=2

Dark silicon problem?

	Post-Dennardian	
ΔN	S^2	S^2
Δf	S	S (集成度高可提速)
ΔC	$1/S$	$1/S$
ΔV^2	$1/S^2$	1
ΔP	1	S^2 散热要 S^2 倍，有限制

↑ 面积比

另一种技术：chiplet ?

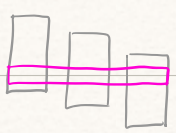
3. Distributed System

History: H/W Infrastructure

硬件容易坏，但 availability

Next { - time 时间同步问题
- data (spatial) consistency

✓ 4. static pipelining 静态调度



Code Movement

4.1 unrolling Loop 循环展开

4.2 S/W pipelining 软件流水

分阶段安排指令顺序