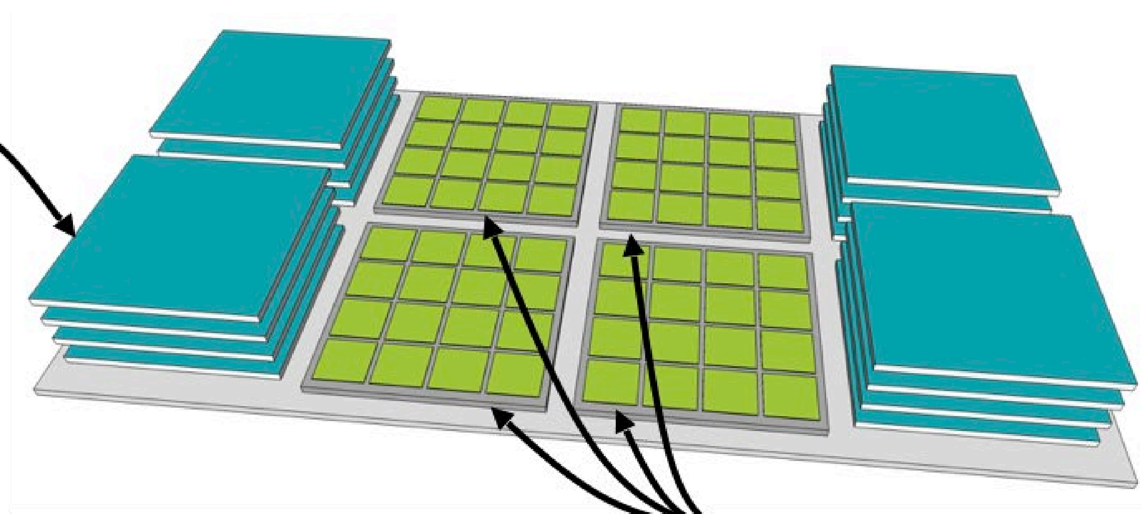
Lecture: Security

- Topics: Spectre and Meltdown attacks, information leakage, integrity verification

UMA

- High Bandwidth Memory uses wiring on a silicon substrate (interposer) to achieve high bandwidth; uses 3D-stacked memory chips to increase capacity on the substrate
- Apple UMA uses similar technology to connect the processor and GPU to high-bandwidth memory – both can access the same memory, so no copies needed



Source: Natalie Enright Jerger, sigarch.org/blog

Hardware Security

- Several types of attacks: physical access to hardware, compromised OS, untrusted co-scheduled applications
- Defenses include: hardware permission checks, encryption, microarchitecture partitions, signature checks, trusted execution environments like Intel SGX
- Information leakage still unresolved – exploited by Meltdown, Spectre, and many subsequent attacks

Meltdown

Attacker code

Fill the cache with your own data X

lw R1 ← [illegal address]
lw ... ← [R1]

Scan through X and record time per access

Spectre: Variant 1

x is controlled by attacker

Thanks to bpred, x can be anything

array1[ ] is the secret

Victim Code

```
if (x < array1_size)
    y = array2[ array1[x] ];
```

Access pattern of array2[ ] betrays the secret

Spectre: Variant 2

Attacker code

Label0: if (1)

Label1: …

Victim code

R1 ← (from attacker)

R2 ← some secret

Label0: if (…)

… …

Victim code

Label1:

lw [R2]

Defenses

- Disable speculation when violations happen (fixes Meltdown)
- Partition resources – has a performance impact
- Several resources involved: bpred, caches, memory controller
- Constant behavior algorithms

Memory Integrity Verification

- Implemented on commercial processors, e.g., Intel SGX
- Confirms that data has not been tampered by malicious agents – attacker with physical access, rogue OS
- Every block has a MAC and a version number
- To prevent a replay attack (attacker sends an old version of data/MAC/counter), a tree of hashes is navigated

Bonsai Merkle Tree