The Internet of Things… and Batteries, Hackers and CPU Architects, oh, and NVM

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What is the Internet of Things?

- Buzzword
- Trend
- Convenient Categorization
- Industrial
- Consumer
- Agricultural
- Medical
- Educational
- All of the above

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Things

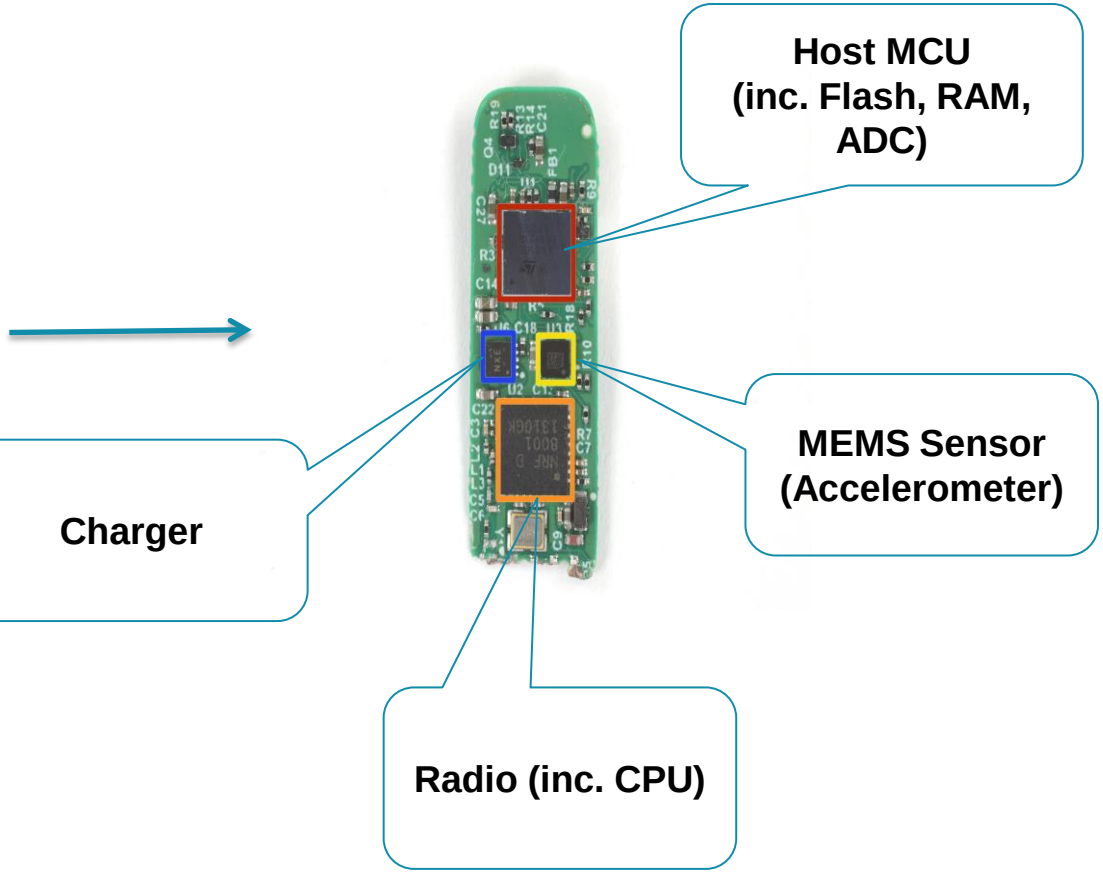
Thing

Thing

Thing

Thing Today: Discrete Components

Will only get more embedded!



Energy

PROBLEM #1

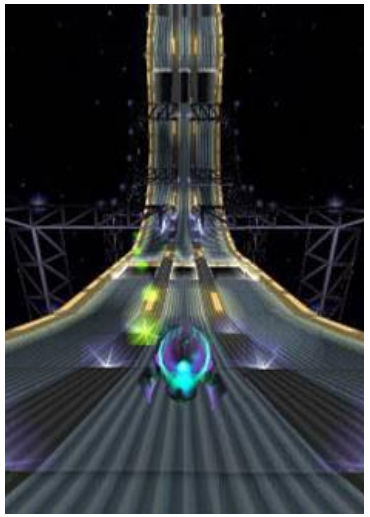
Batteries Don’t Follow Moore’s Law

1998 Nokia 5110

- Screen 47x84 B/W display
- 64K RAM, 1MB Flash
- 16 buttons
- Entertainment – ‘Snake’
- Battery 900mAh

2012 Samsung Galaxy S3

- 4.8inch 1280x720 HD display
- 2GB RAM, 16GB Flash
- Touch screen input
- 8-megapixel camera with HD video
- 2D/3D graphics acceleration
- Stereo speakers with 3D audio
- Battery 2100mAh



Use Cases Imply Power Envelope

- Smaller batteries lasting longer? All depends on usage
- Some IoT devices need to last years (eg. distributed sensors)
- Lets all agree, more battery life is always a good thing

What's the Real Problem?

HP >
Cost >
Top Speed >

NO GOOD

GOOD

What's the Solution

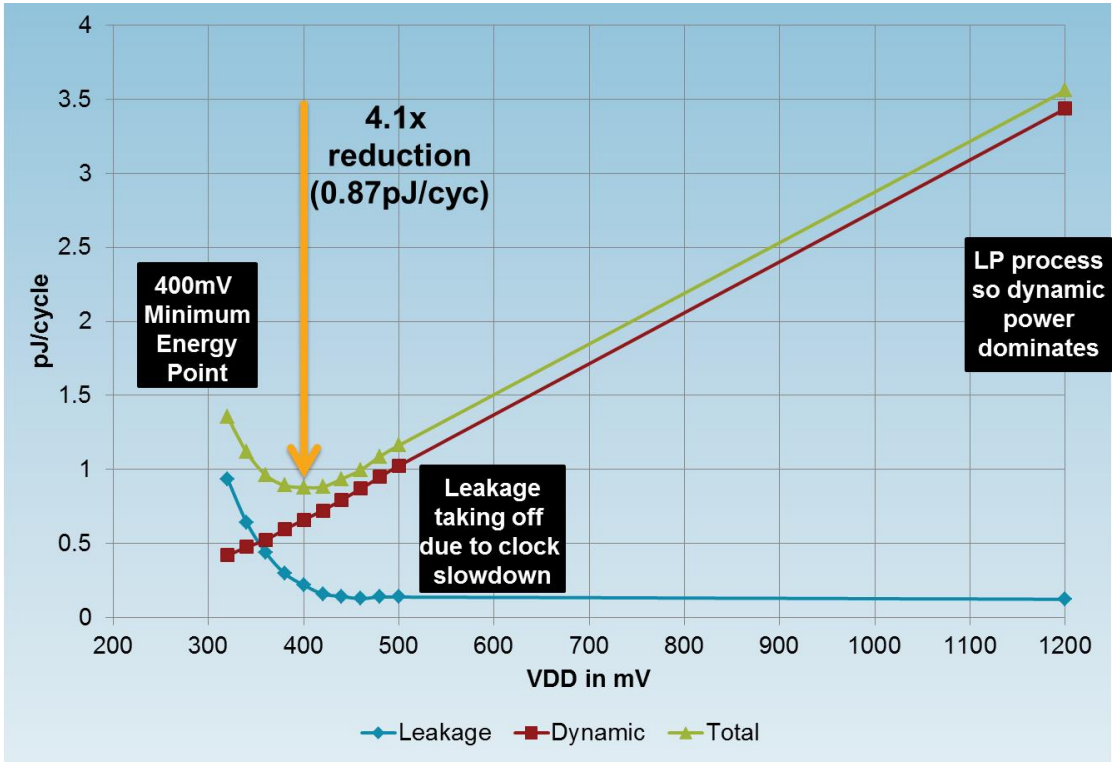
More HP?

"Fix" Track?

This one!

The Chassis?

Cortex-M0 Energy/Cycle

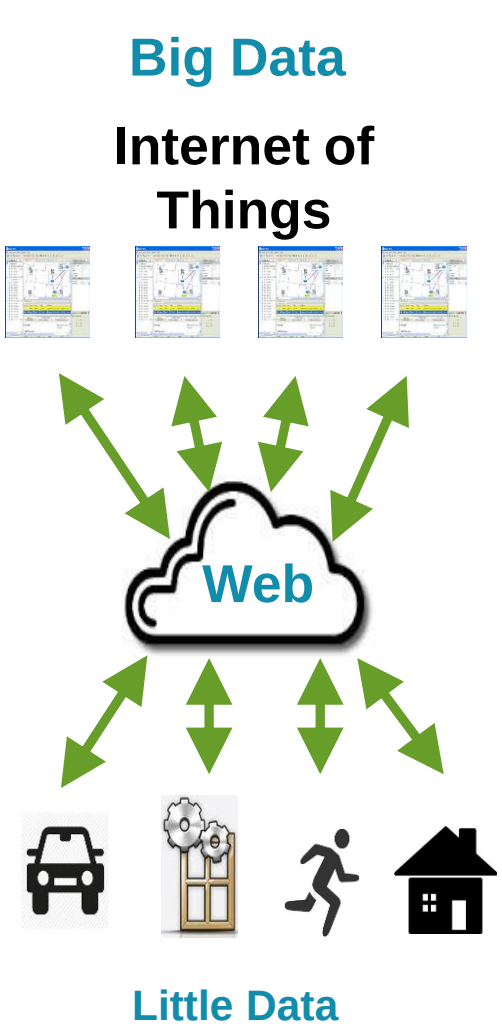


- Cycle 10000 logic gates same energy as writing/erasing 1 bit of FLASH
- FLASH is a huge problem as it's energy does not scale
- IoT devices need to last longer on smaller batteries

Security

PROBLEM #2

Everything Connected



Must be safe, seamless and simple

Services

- Power efficient servers
- Fast, high capacity storage

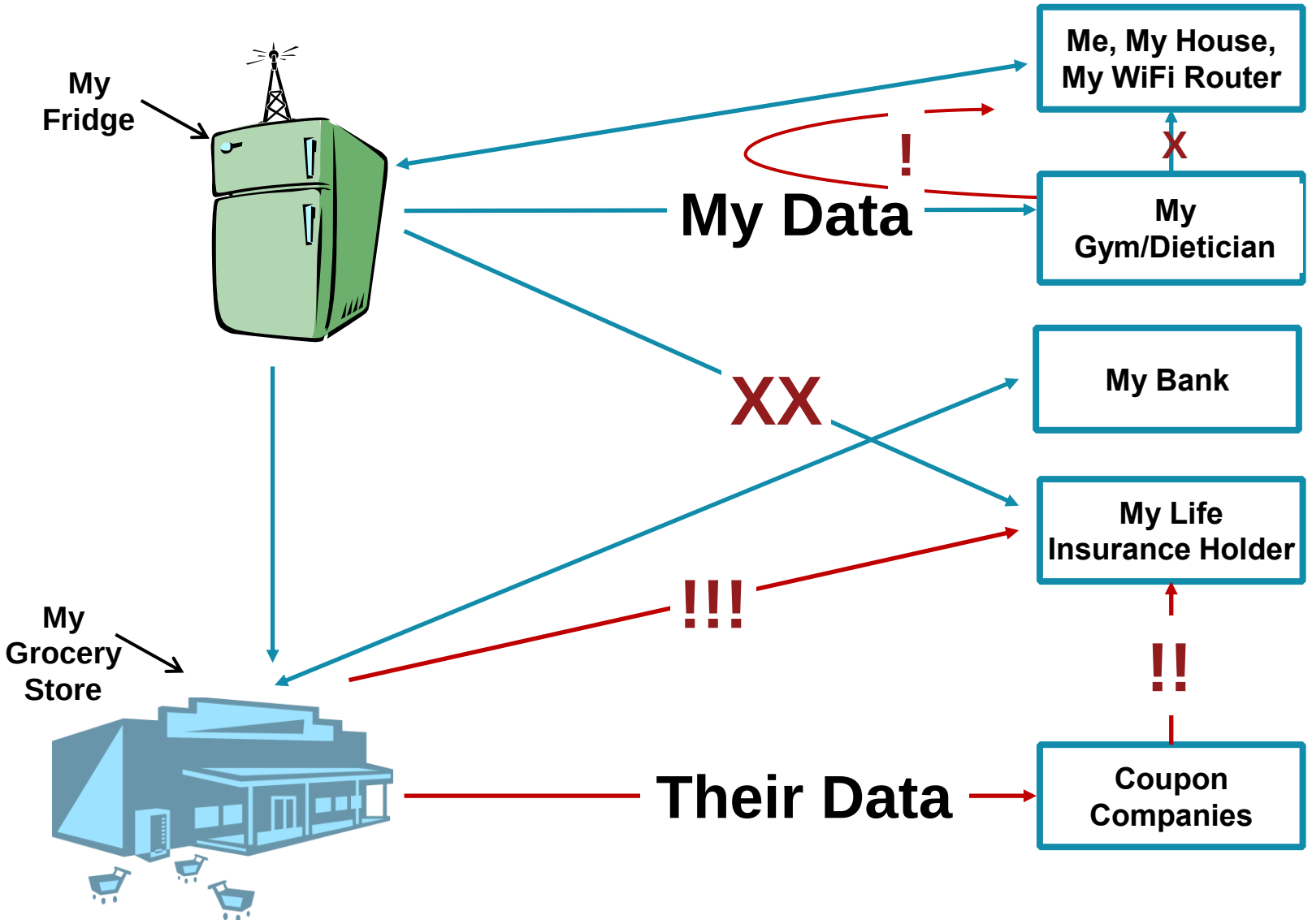
The Web

- High throughput networks
- Low power wireless networks

Things

- Integrated sensors and computing
- Ultra low power systems

Data Ownership and Protection



Oh Boy!

Belkin WeMo smart home networks in danger of hacks

Researchers warn that more than 500,000 home automation devices have vulnerabilities that would allow attackers to remotely take control of thermostats, lighting, sprinkler systems, and more.

by Dara Kerr @darakerr / February 18, 2014 6:10 PM PST

NEWSFEED BIZARRE

Stranger Hacks Into Baby Monitor and Screams at Child

Olivia B. Waxman @OBWax | April 28, 2014

- Your “things” need the same security as your bigger things, no matter how much or little they cost
- Cliché time: “you are only as strong as the weakest link”

Cost is Key in Security

Product Cost

% Cost of product that is security related

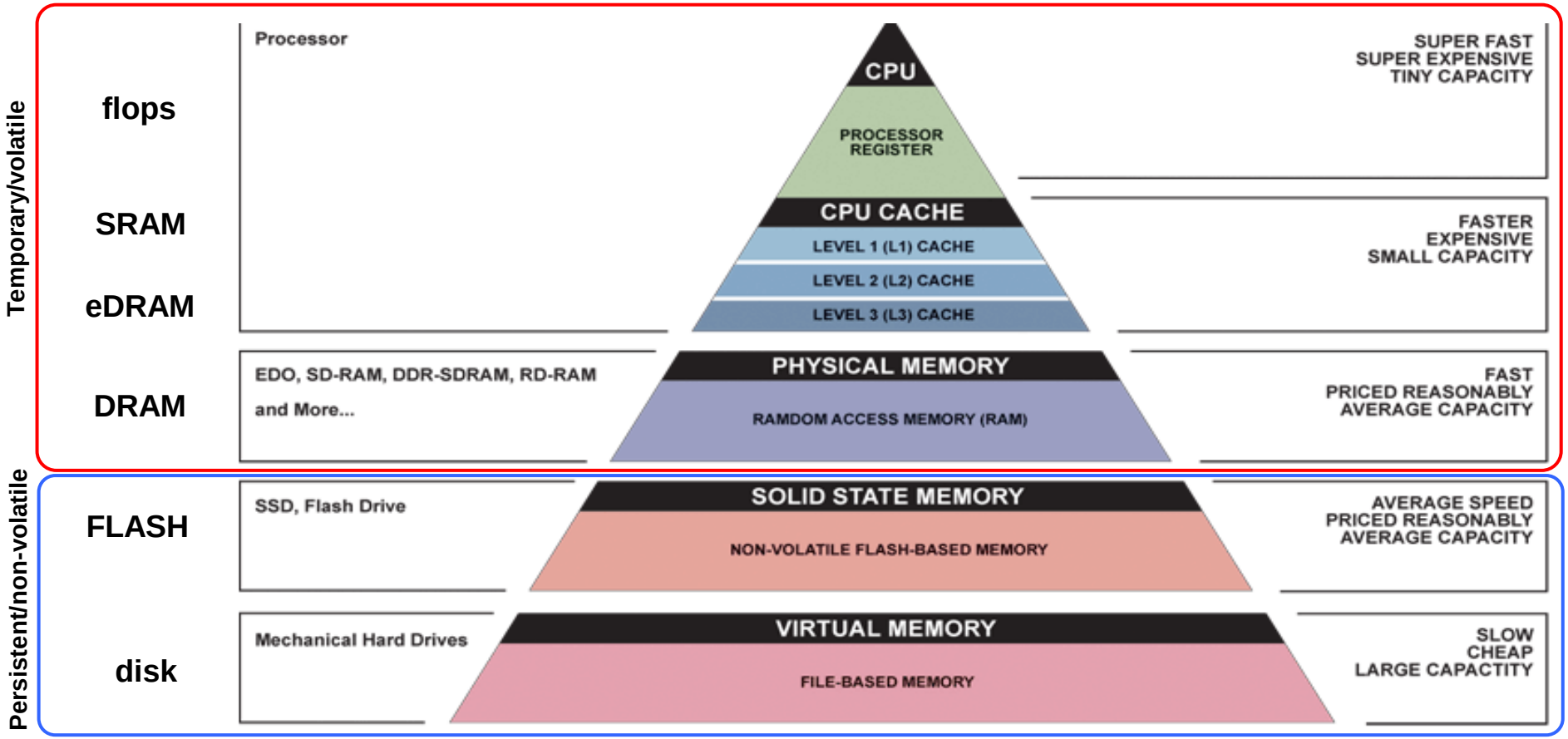
- Security needs NVM and FLASH is very expensive (cost and energy)
- OTP does not allow firmware/security updates
- IoT much more cost sensitive to security requirements

Endurance

PROBLEM #3

Memory and CPU Today

- Memory hierarchy retained, levels are added (such as eDRAM) but the hierarchy is untouched

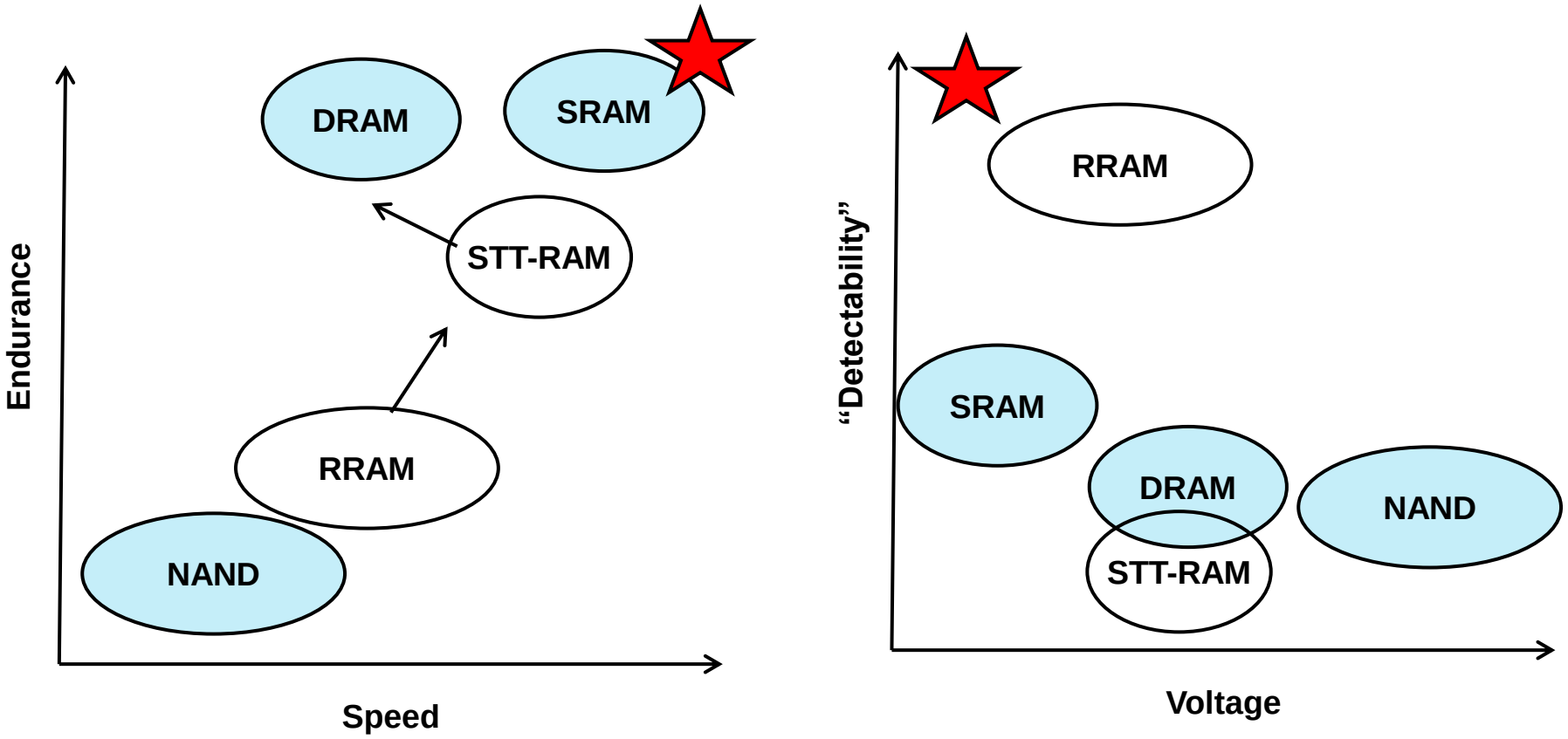


Wanted: Super Memory

	SRAM	DRAM	NAND	SuperMem
Area (F^2)	~120	4-6	<4 (eff)	<=6
Write Speed	<300ps	10ns	50ns+	<1ns
Read Speed	<300ps	10ns	10ns	<1ns
Leakage	High	Low	0	0
Active Power	“Low”	Low	High (write)	Low (1pJ/bit)
Nonvolatile	No	No	Yes	Yes
High Voltage	No	No	Yes	No
Logic process	Yes	No	No	Yes
Endurance	Infinite	Infinite	10^5	>10^15

- Super Memory needs to scale
- No alternative (yet) for embedded SRAM, but nonvolatile would have big implications
- Which will win? MRAM? RRAM? TBDRAM?

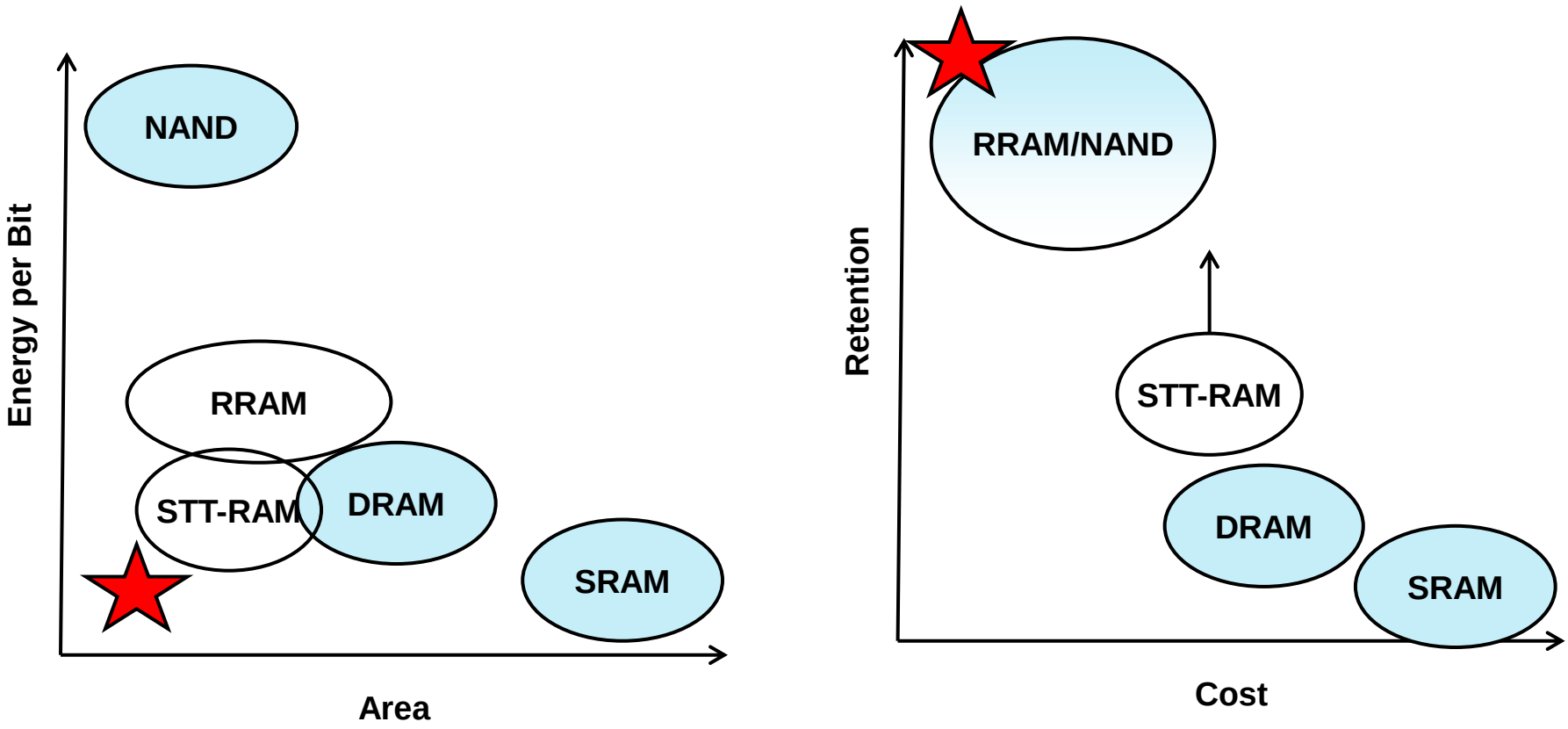
The State of the Art (Part 1)



- Detectability is a measure of the difference between 0 and 1 (how much ECC/write/read assist needed)
- Speed is indicative of read/write performance

★ = Super Memory

The State of the Art (Part 2)



- Retention for STT is on the order of weeks/months (depending on write), RRAM etc. is on the order of years
- Cost includes area plus processing/test

Endurance Requirements for System Memory

Endurance Requirement

Chance of Universal Memory

- Endurance is most likely limiter to universal memories
- Many IoT devices will have low enough cycling that new NVM could be universal (need at least 10^{10})
- This could allow ultimate power management (instant on/off with all memory non-volatile)

Wrap Up – Where We Stand

- Could we land up with a mix of flavors?
  - Charge RAM (the incumbents): Flash, DRAM, SRAM
  - Resistive RAM: RRam, CBRAM, PCM, CeRAM
  - Magnetic RAM: STT-MRAM, FeRAM , TAS-MRAM
- For MCU/IoT NVM
  - RRAM preferred due to cost/density
  - DRAM replacement leaning towards MRAM
    - If MRAM replaces DRAM, will replace FLASH (and ReRAM) too
  - SRAM replacement is SRAM
- New NVM could influence future CPU architectures especially in the low power arena