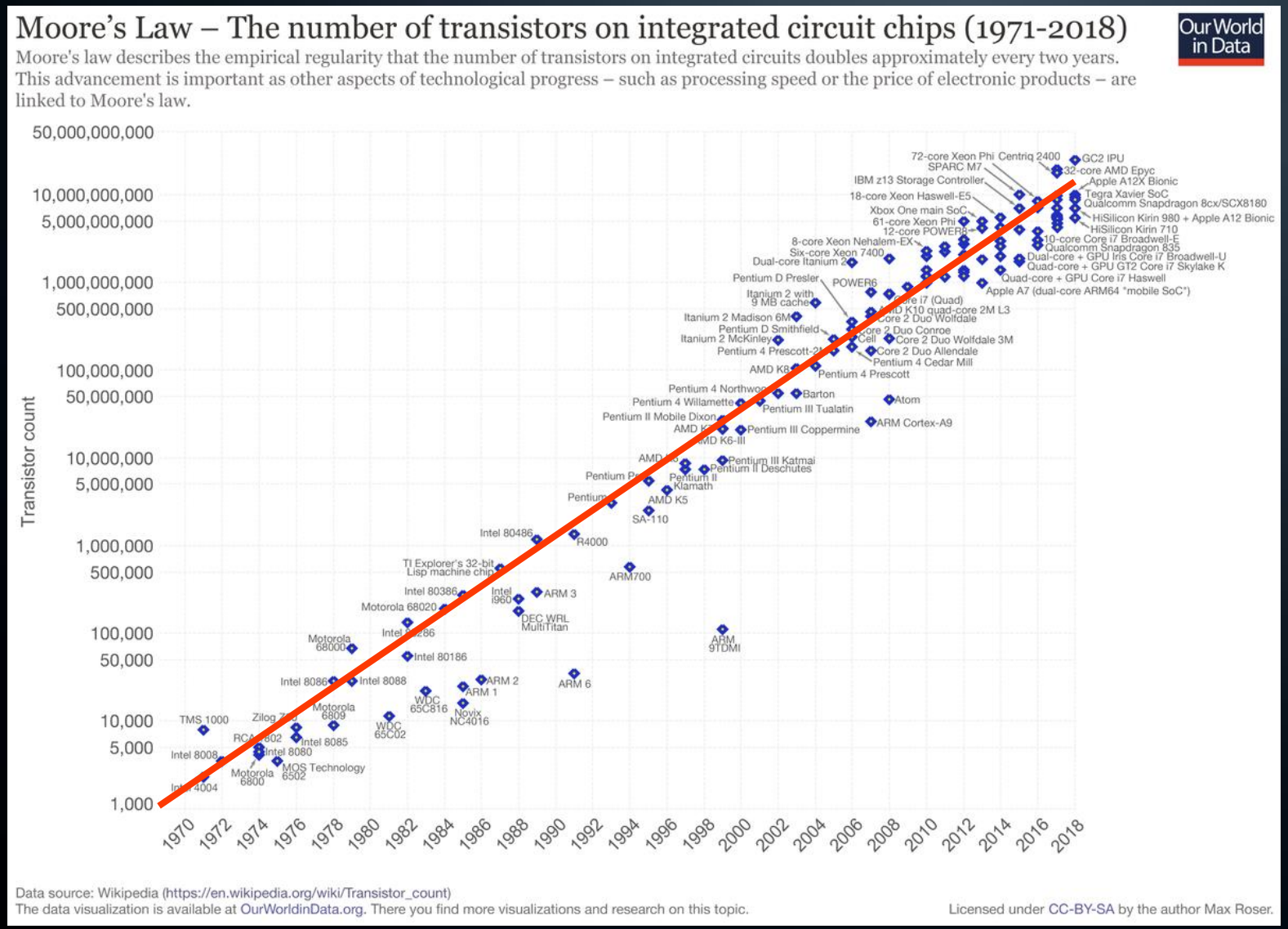
Get MOoRE out of the Package

IMAPS Program:

- ***"Integration": 46x***
- ***"HETEROGENEOUS": 19x***
- ***"Chiplet": 10x"***

MARVELL®

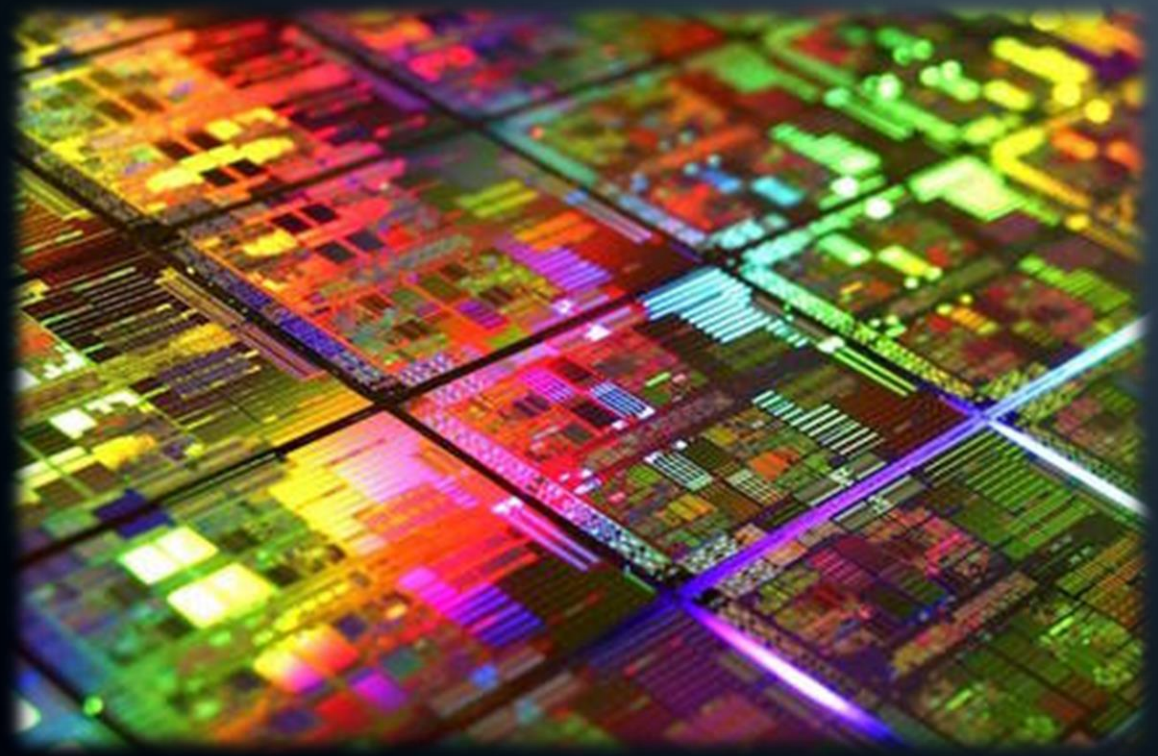
Interpretations of Moore's Law

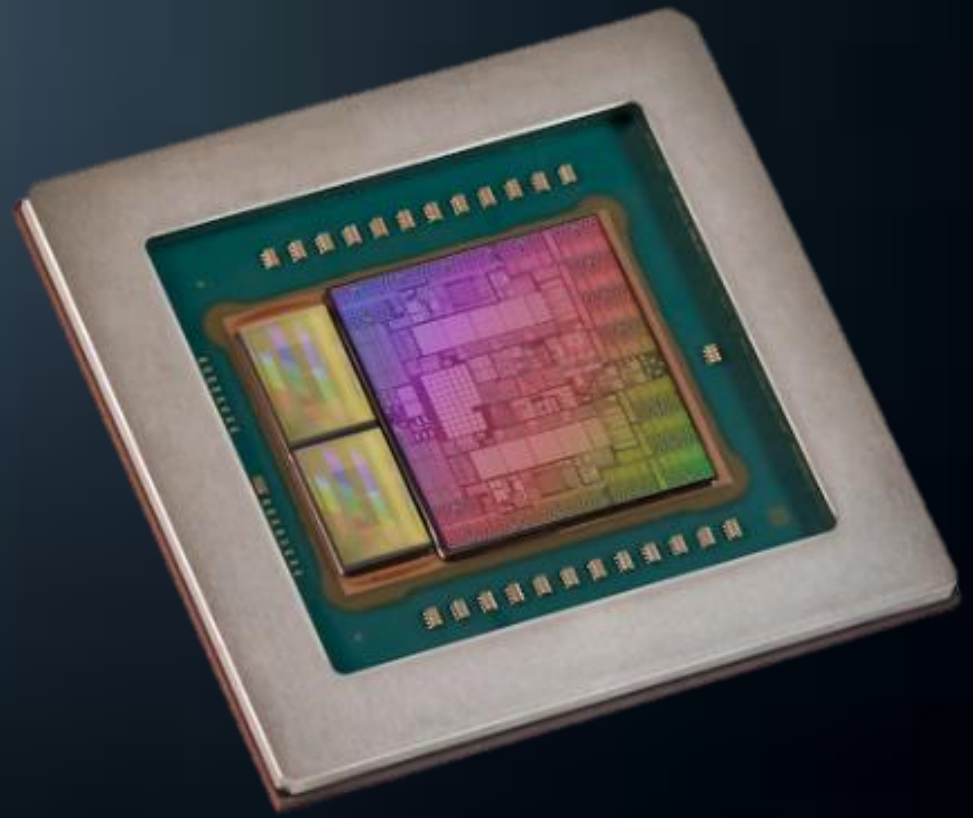


- Is it Technology Scaling?
- Is it Economic?
- Is it Performance?
- Is it Function?
- Is it an Observation?
- Is it all of the Above?

- Or does it not matter?

Products are Modules, not Chips



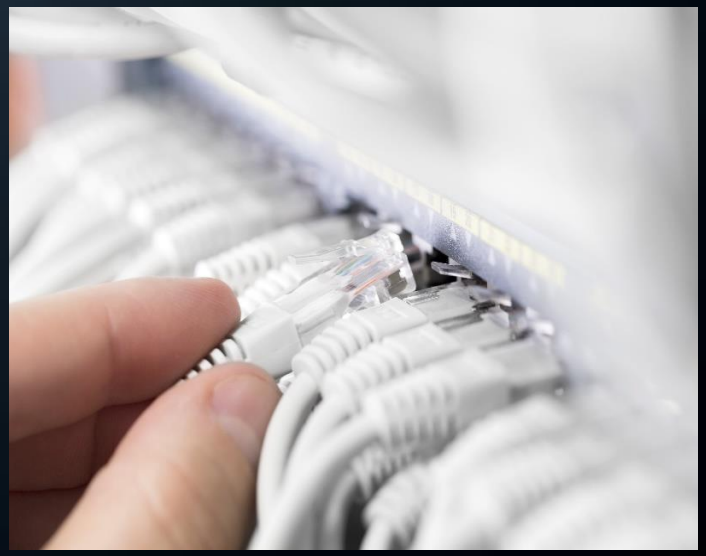


What Do Next-Generation Products Need?

Wireless / 5G Infrastructure

Compute

Networking

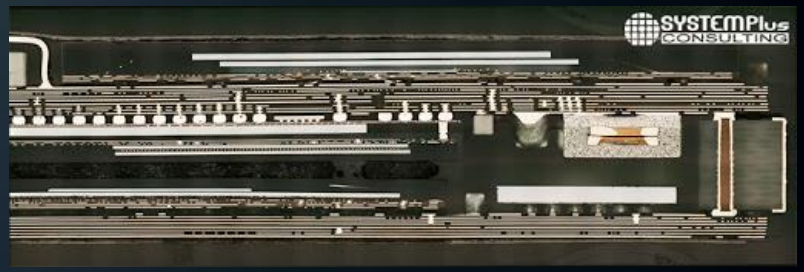


What Do Next-Generation Wireless Products Need?

Wireless / 5G Infrastructure

Handheld

- Ultimate density requirements
- Memory integration
- RF Integration
- Next Gen for Power & Perform.
- Cost



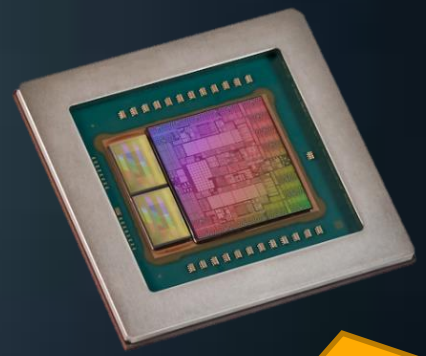
Wireless Infrastructure

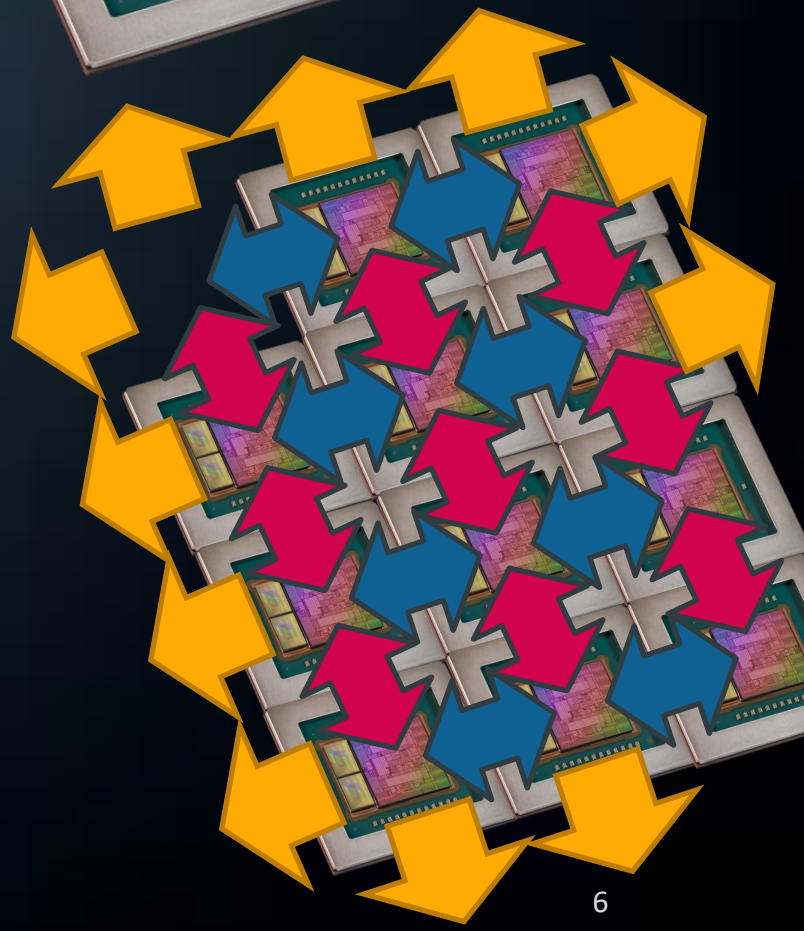
- Antenna (array)
  - RF integration
  - Power
  - Cost
  - Small Area
  - Thermal
- Baseband
  - Modularity
  - Power
  - Cost
  - Thermal

What Do Next-Generation Compute Products Need?

- Performance
  - Next Gen Technology
- Power efficiency
- Cost
- Memory bandwidth
- Scalable compute systems with high C2C bandwidth
  - Drives huge bandwidth between chips
  - (e.g. CHIPS, Cerebras)

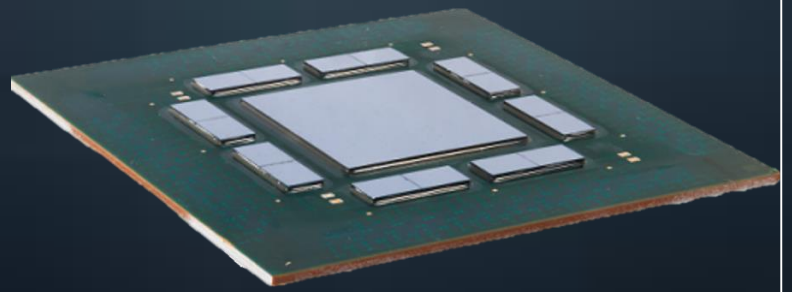
Compute





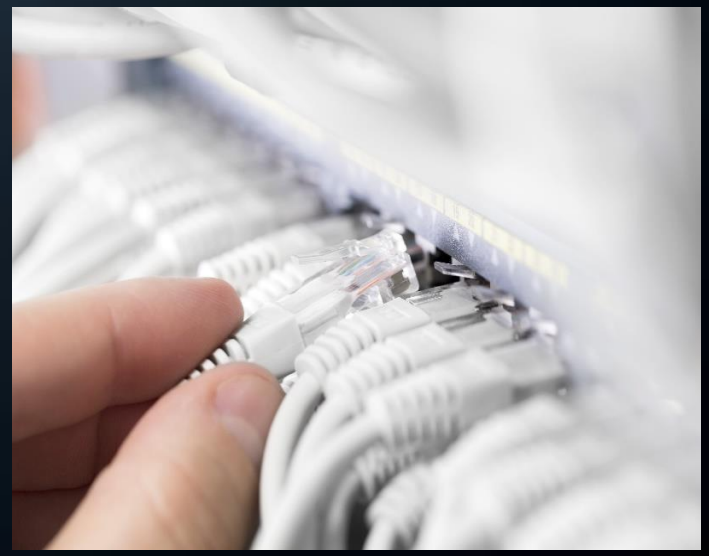
What Do Next-Generation Networking Products Need?

- More Si Area than can fit in a reticle
- More bandwidth
  - Between chips
  - Off-module
- Larger package
- Lower package loss
- Huge amount of power
  - Coupled with HBM integration



Marvell Falcon 12.8T Switch

Networking



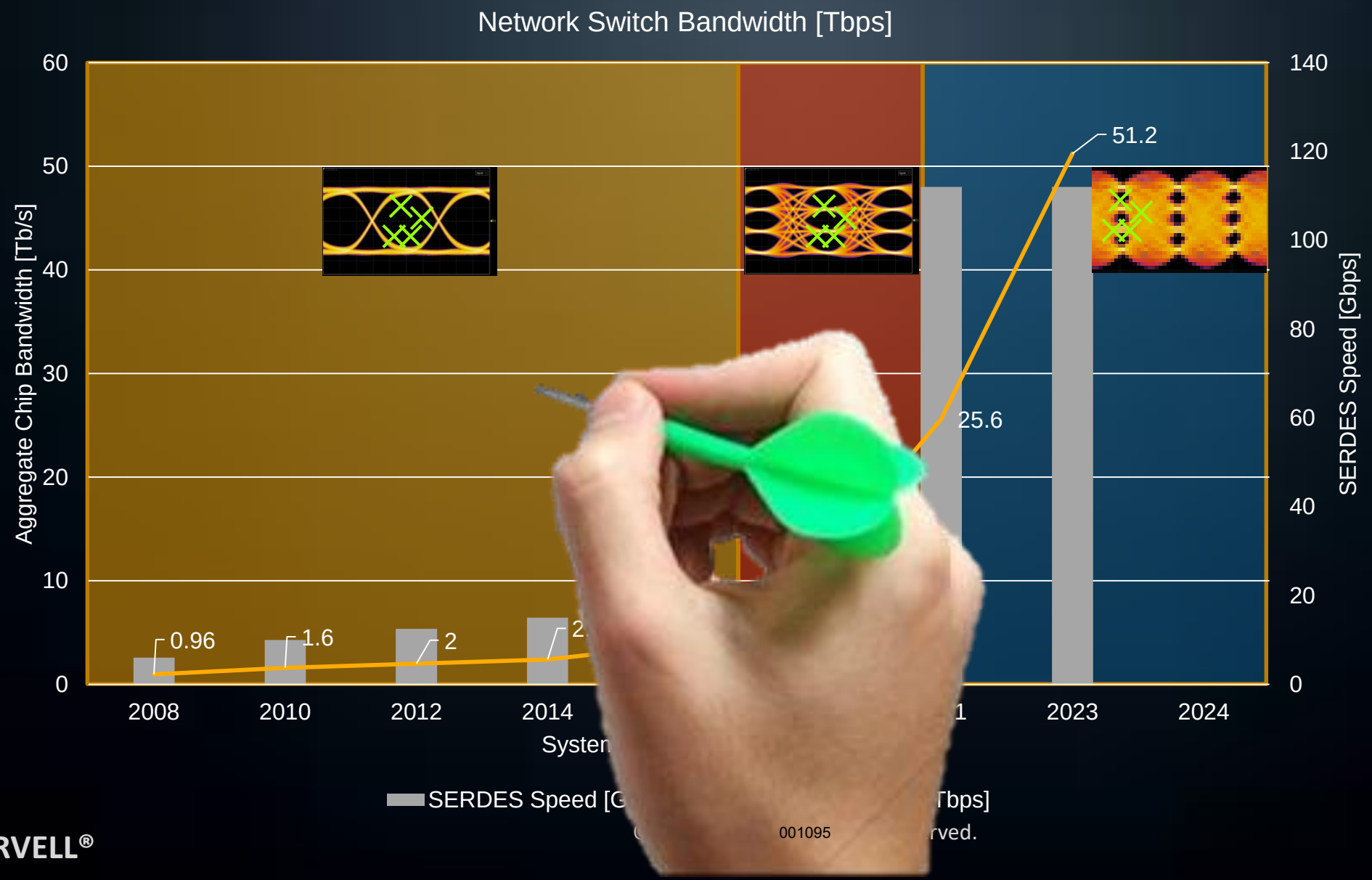
Forget about the Chip

Get MORE out of the Package

OK… but More WHAT?

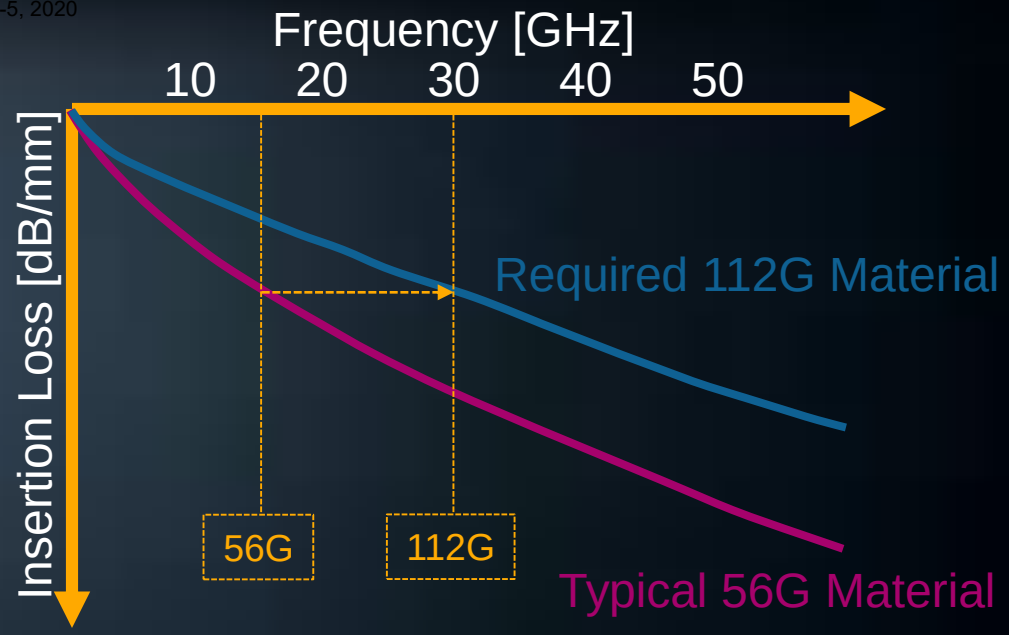
- Get more data out of the package
- Get more functionality out of the Package
- Get more cost out of the package

Get more Data out of the Package: Network Switch Roadmap



What happens at 112G?

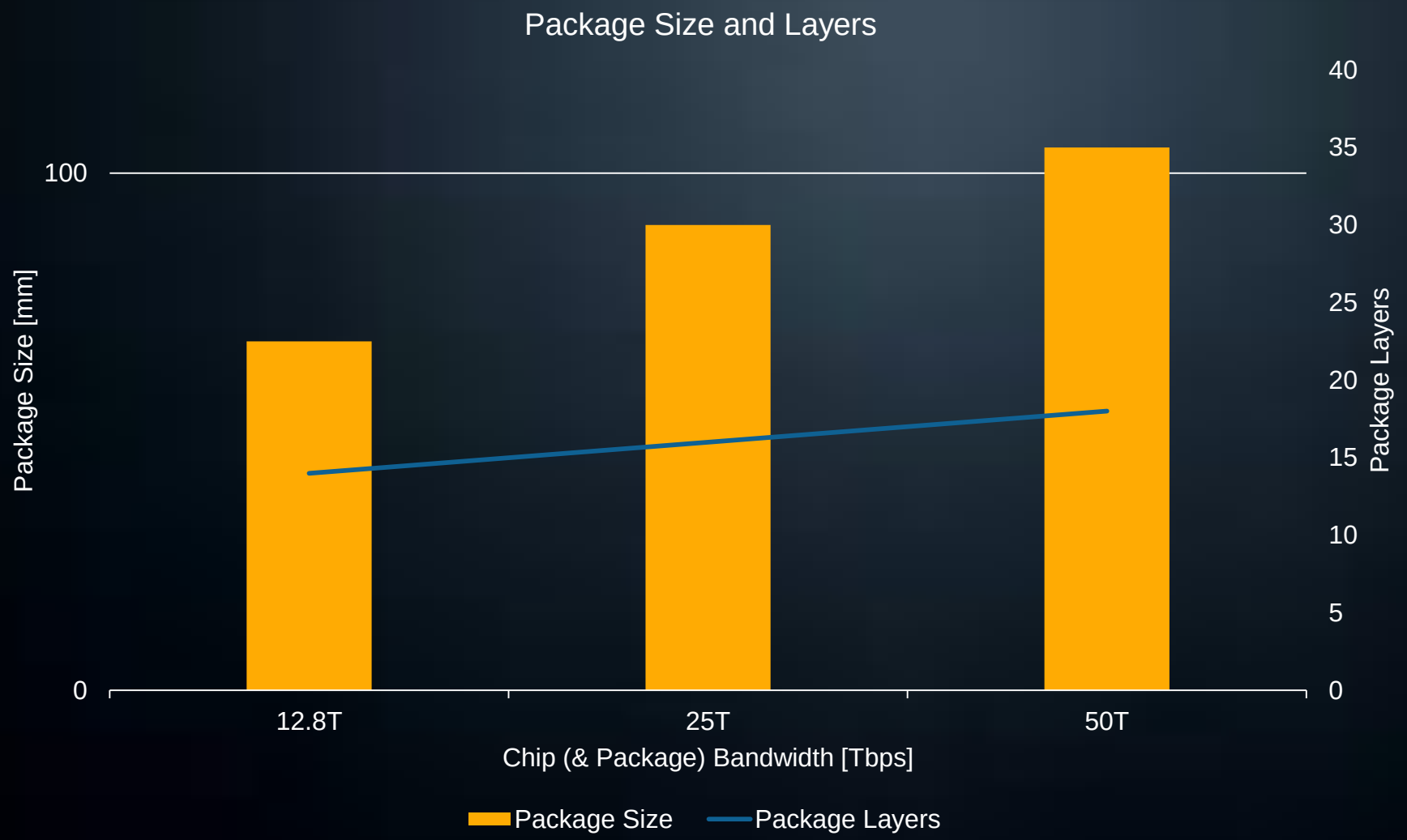
- Insertion loss doubles (relative to 56G)
  - But Package IL Budget doesn't increase
  - Need 2x better package materials



- Signal Integrity drives extra BGA Isolation
  - BGA area needed for 4 lanes of SERDES
  - More SERDES lanes per Chip
  - → Package Size grows

- Many SERDES lanes → many wires
  - Drives more build-up layers

50T Switch – What kind of Package does it Need?



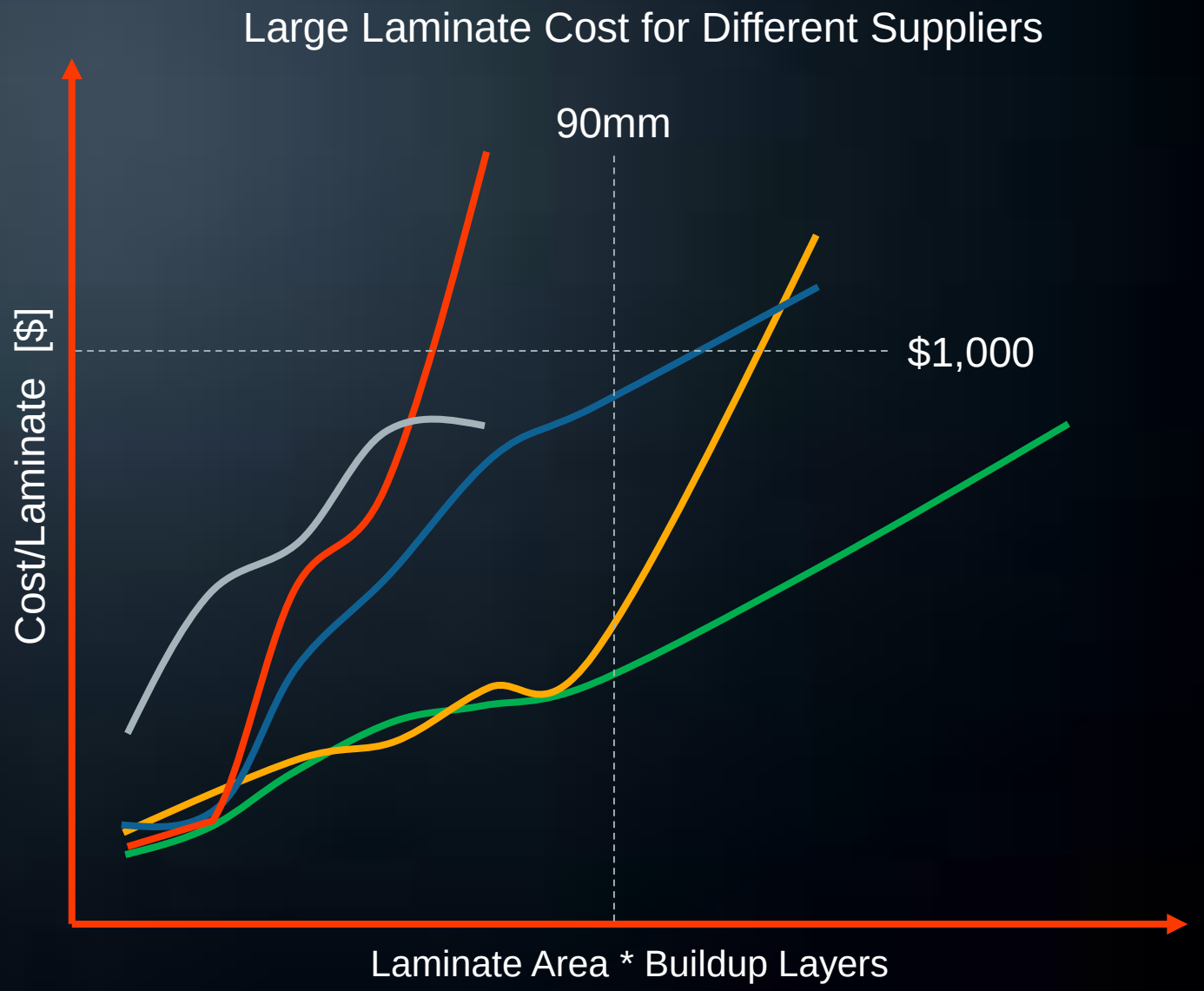
- Significant increase in package size and complexity

Large Laminate Cost

Large Laminates will be in products within the next 2 years, BUT:

- Cost is very inconsistent
- Cost is very high
- Not many suppliers supporting very large sizes

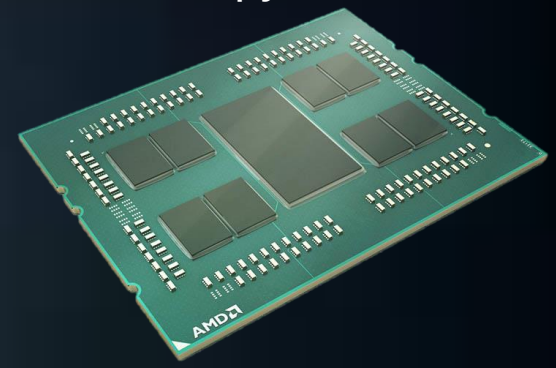
➔ Appears that laminate suppliers are hedging their bets



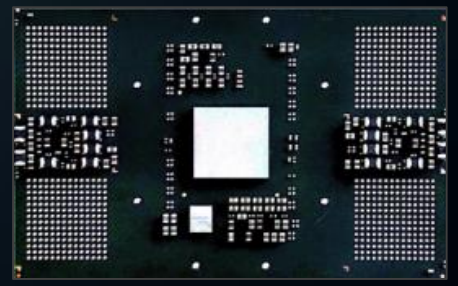
Get More Function out of the Package

- Different functions don't always want to be on the same chip
  - IO Function
    - Schedule
    - Modularity
  - Analog and RF content
    - Technology fit
    - Modularity
  - DRAM
    - Technology fit
    - Cost

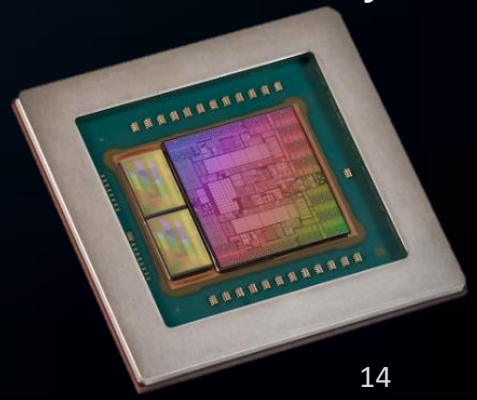
AMD Epyc 2 Rome



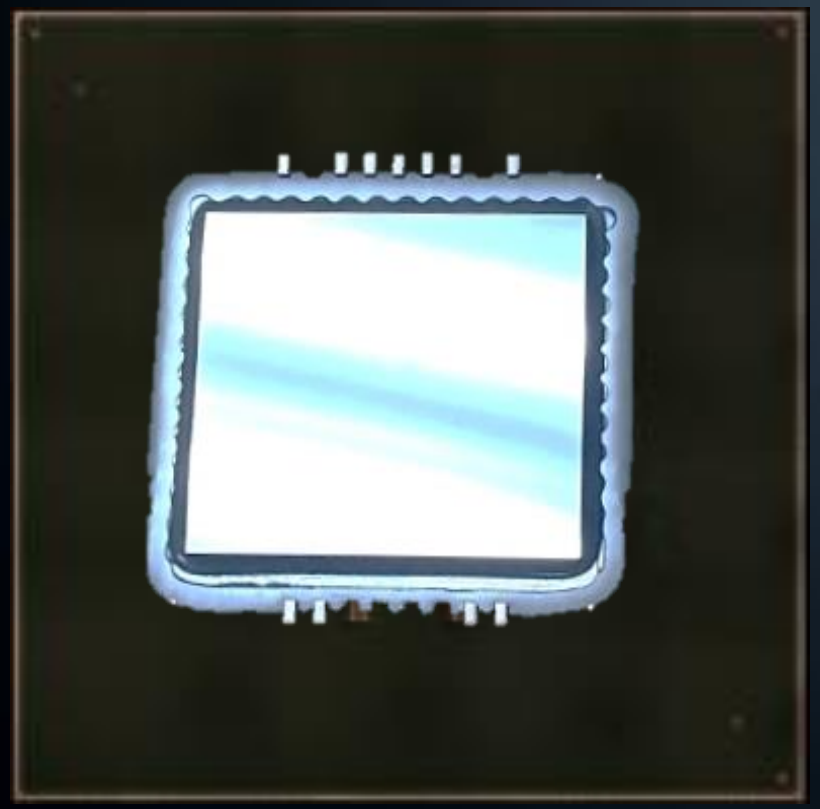
Data Converters



HBM Memory

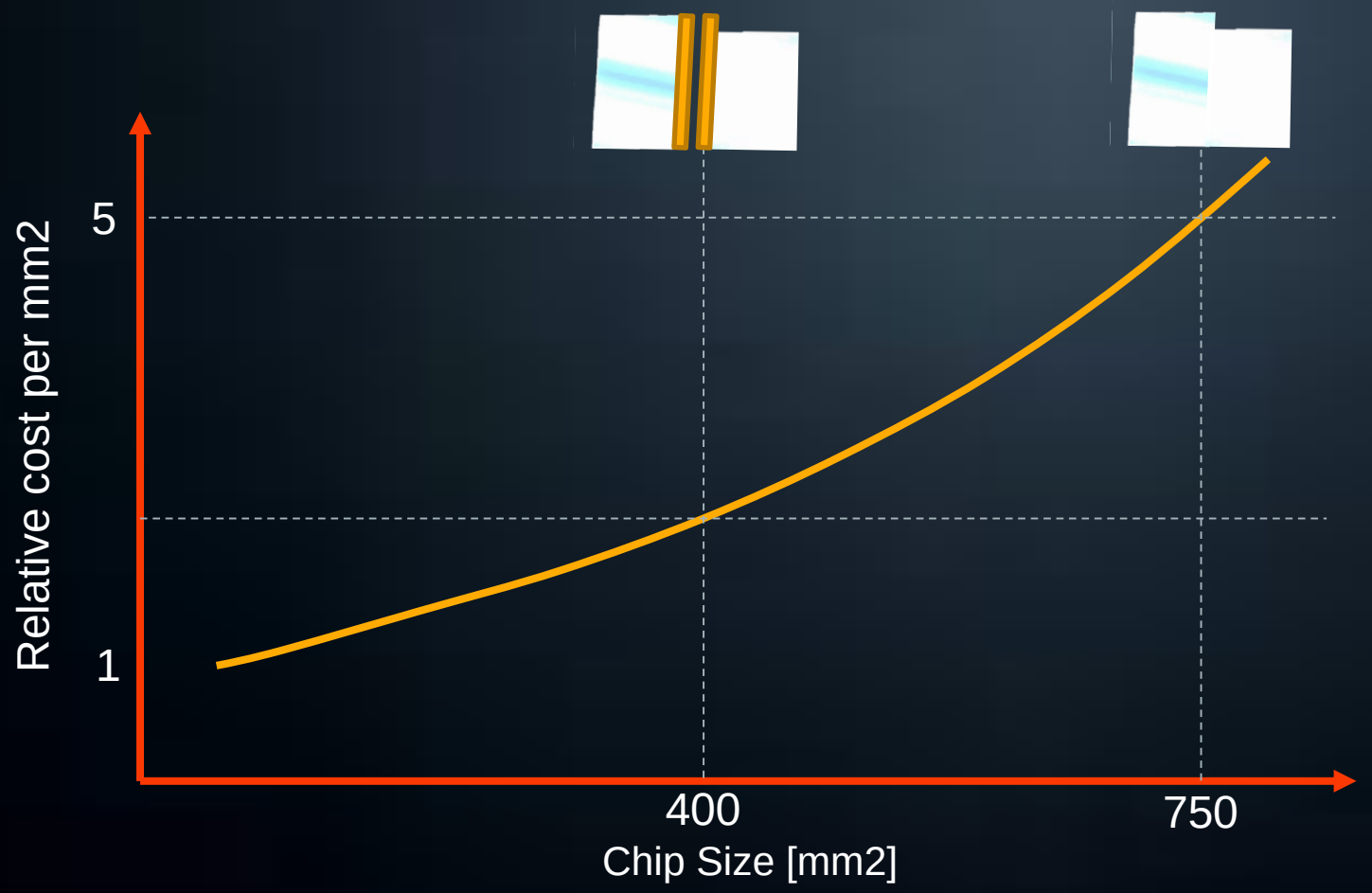


Get More Cost out of the Package



- Chip-to-Chip interface is required
- ➔ Chip partitioning actually increases the total Silicon Area

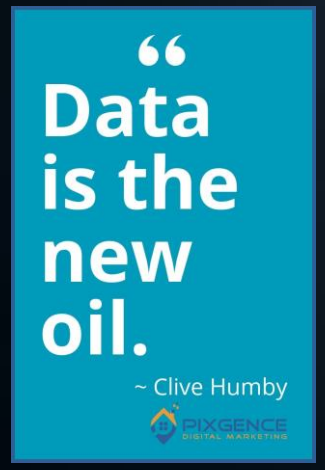
Cost of Yield Curve – Mathematical



- Large die yield poorly
  - ➔ high cost per mm^2
- Smaller die yield significantly better
  - ➔ much lower cost per mm^2

What about that Chip-to-Chip Interface

Let's try an analogy:



Data = New Oil

Steven Solomon, Contributor
Author, “Water: The Epic Struggle for Wealth, Power, and Civilization”

Water Is The New Oil

03/18/2010 05:12 am ET | **Updated** May 25, 2011

Water set to become more valuable than oil

Suez CEO says water scarcity was one of the biggest challenges facing industries

Water = New Oil

Data = Water

Some Water (or Coke) – i.e. Some Data

Small pipe works well

A lot of Water – i.e. A Lot of Data

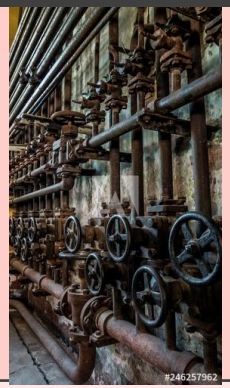
Small pipes don’t work so well

A much bigger pipe is needed for a lot of Data

- A huge amount of water/data typically requires a much bigger pipe

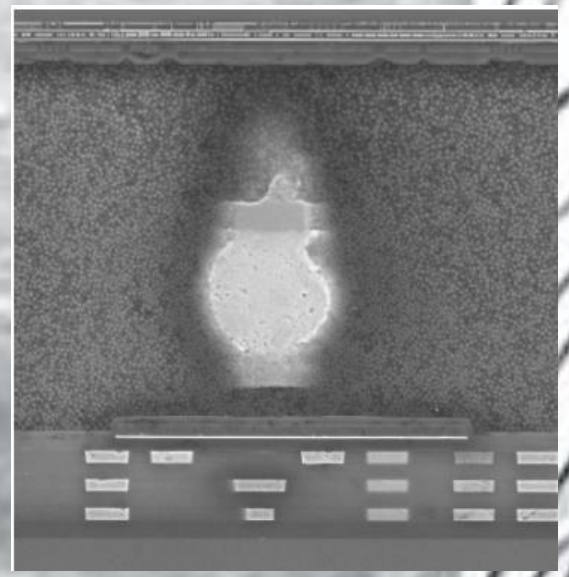
Chip-to-Chip Interfaces

- Several proposals exist for generic interfaces
  - Each of them have Pro's and Con's
  - It is unclear if the industry will corral behind just one of them

Interface	112G XSR	OCP "BoW"	Parallel, e.g. AIB
Analogy			
Signal Speed	112 Gbps	5 - 32 Gbps	2 - 5 Gbps
Standard	OIF	OCP (ODSA) Proposal	Open Standard (Intel)
Package Technology	Standard	Standard / Advanced	Very Advanced

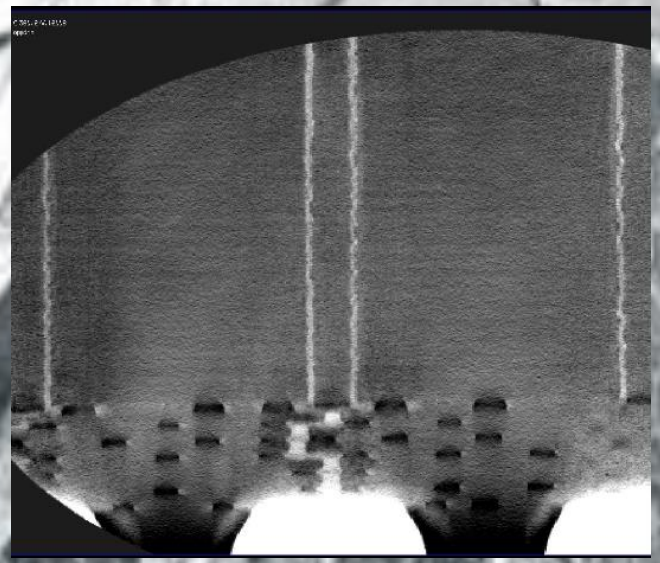
Wiring Comparison

Silicon Interposer



1x1

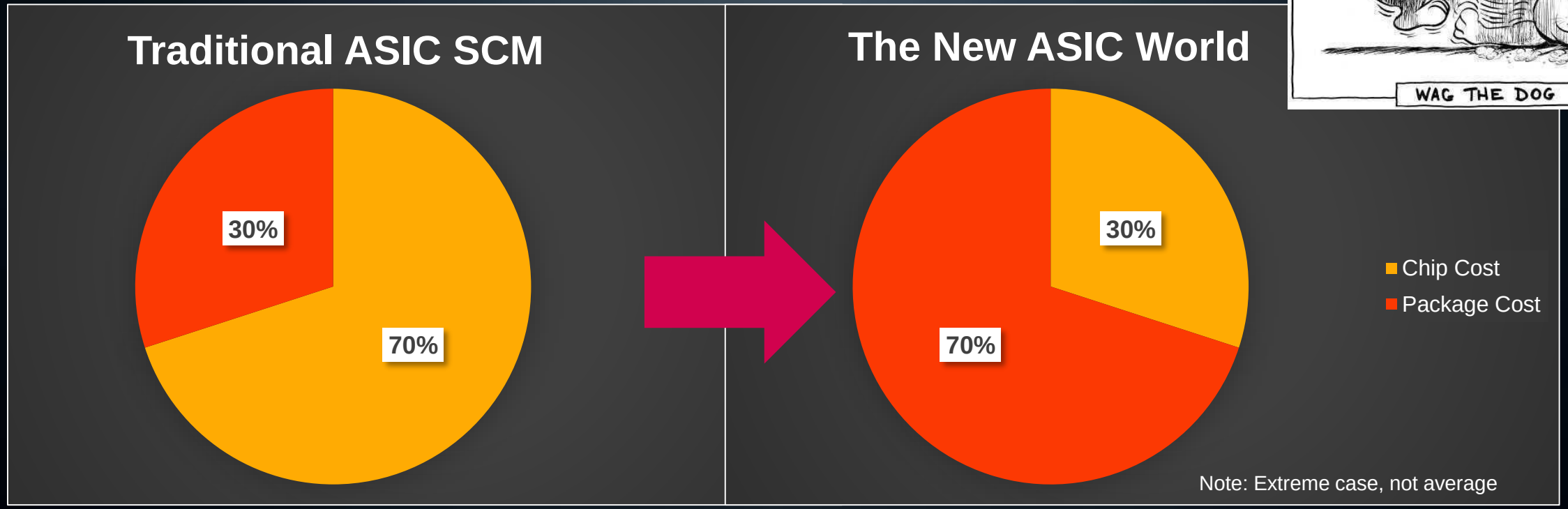
Laminate



20 x 15

75um Human Hair (average)

Cost-Evolution of Chip vs. Package

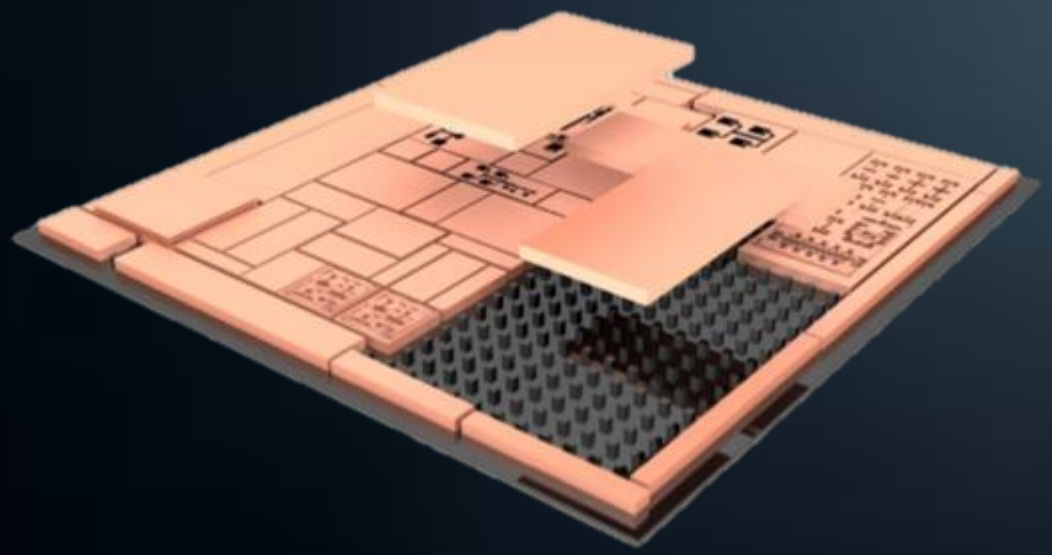


- Package cost on complex products can now far outweigh chip cost
- Interface definition is what drives one package technology (and cost) vs. another

Hard vs. Valuable

Value generally keeps increasing as things get harder

Standards, Chiplets, Open Access

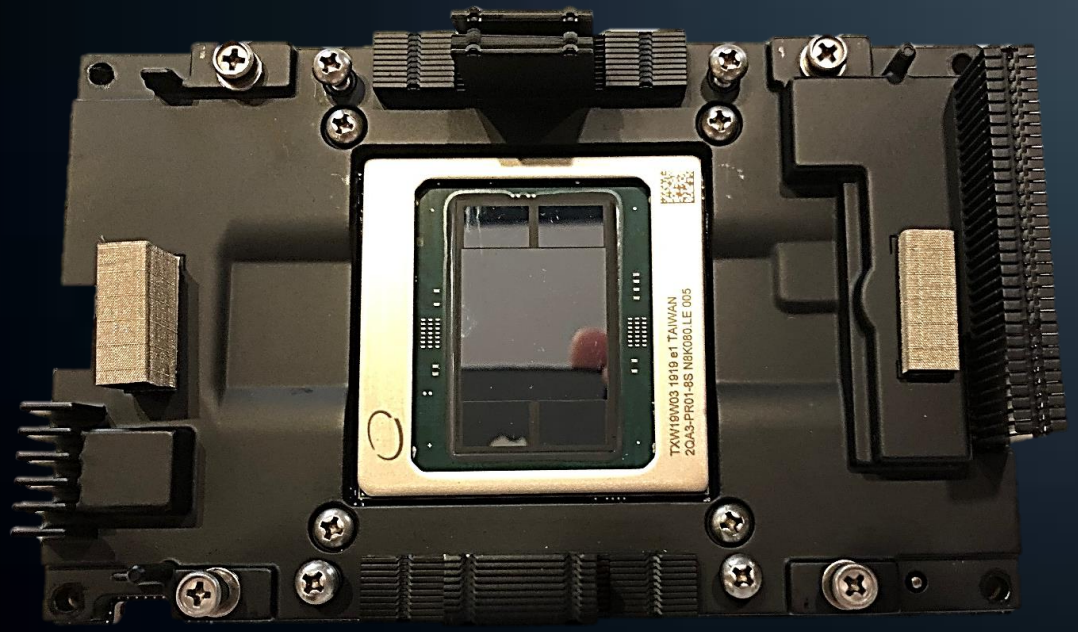


Semiengineering

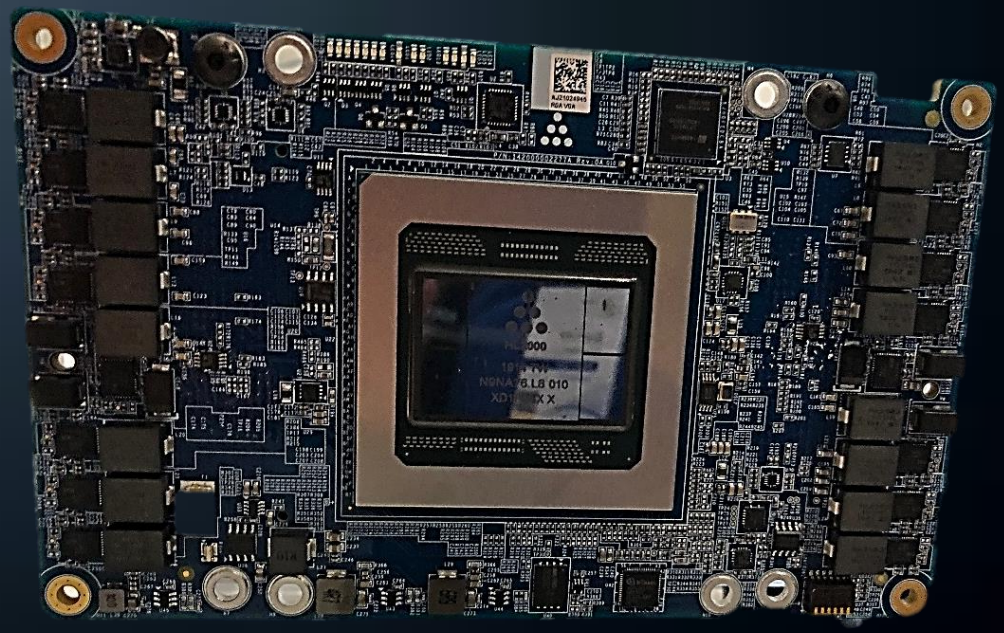
- Chiplets offer many significant advantages
  - Transition to chiplets has begun, and will continue to gain momentum
- But also harbor significant challenges
  - Drives new business models
  - Cost, yield and ownership considerations
  - Commodification of really “hard stuff”

OCP Open Accelerator Module

Intel “Nervana”
(TSMC based)



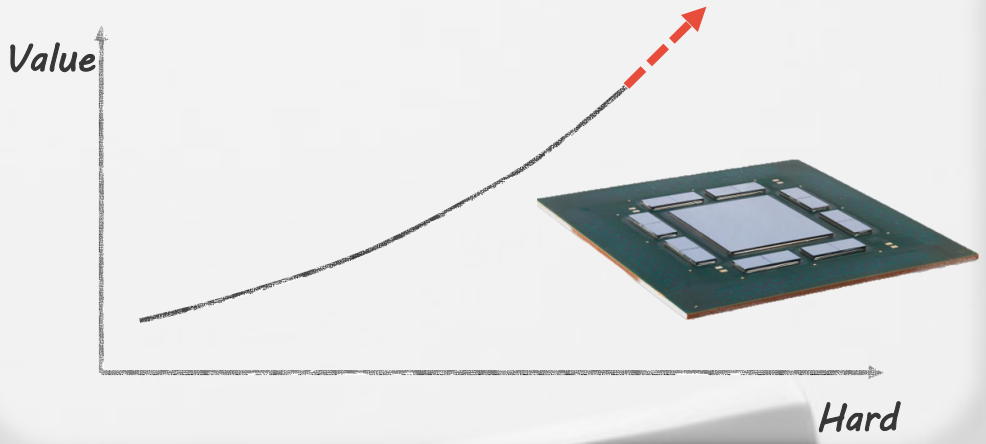
Pin-compatible Accelerator from
“Habana”



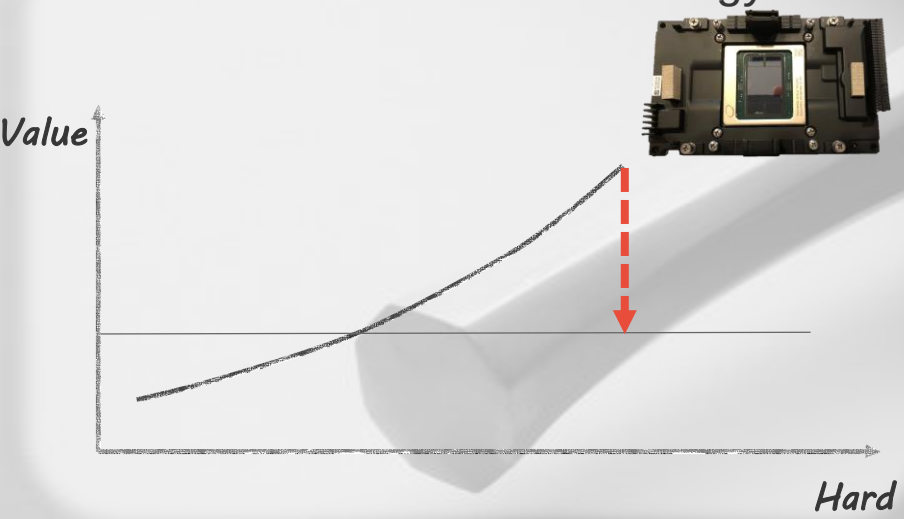
- AMD, Baidu, nVidia also providing compatible cards

The Double-Edged Sword of Standards

Technology Evolution & Revolution



Commodification of Technology



001112

A typical Meeting Agenda in the Semiconductor World

Up to ~2017:

Agenda

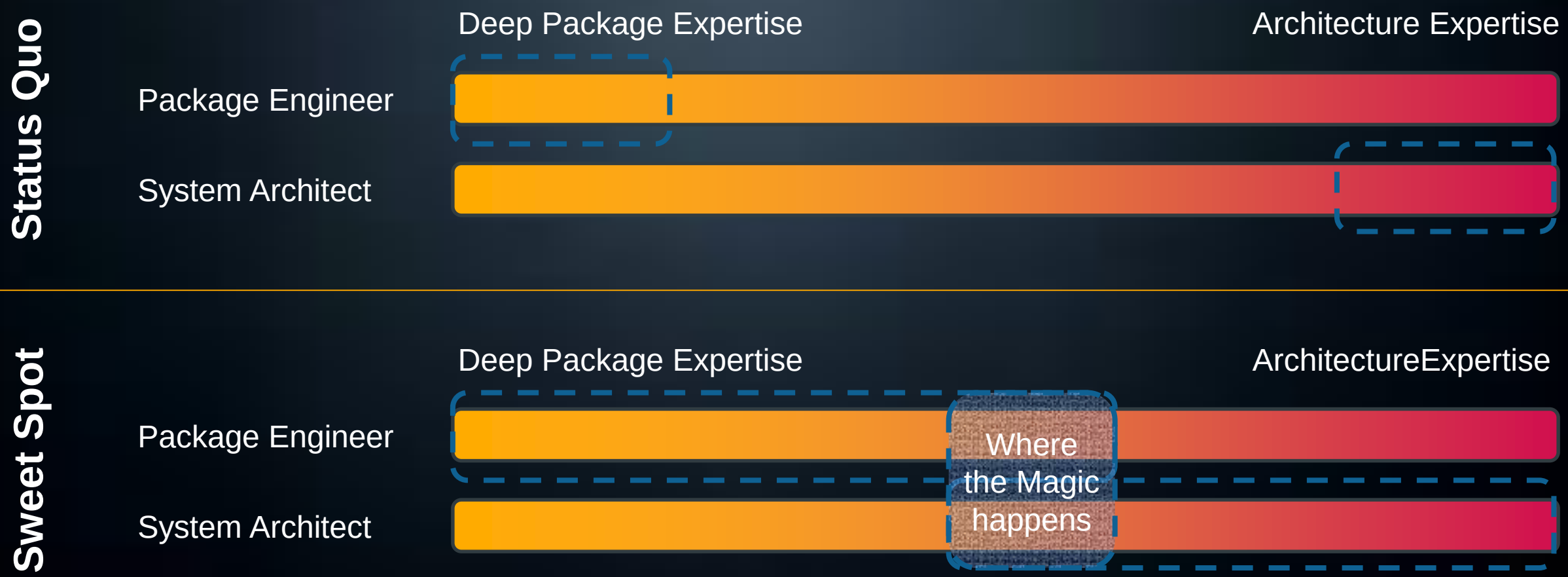
- Chip Size
- Chip Performance
- Chip Color
- Chip Taste
- …
- (Packaging) – if time allows

Now:

Agenda

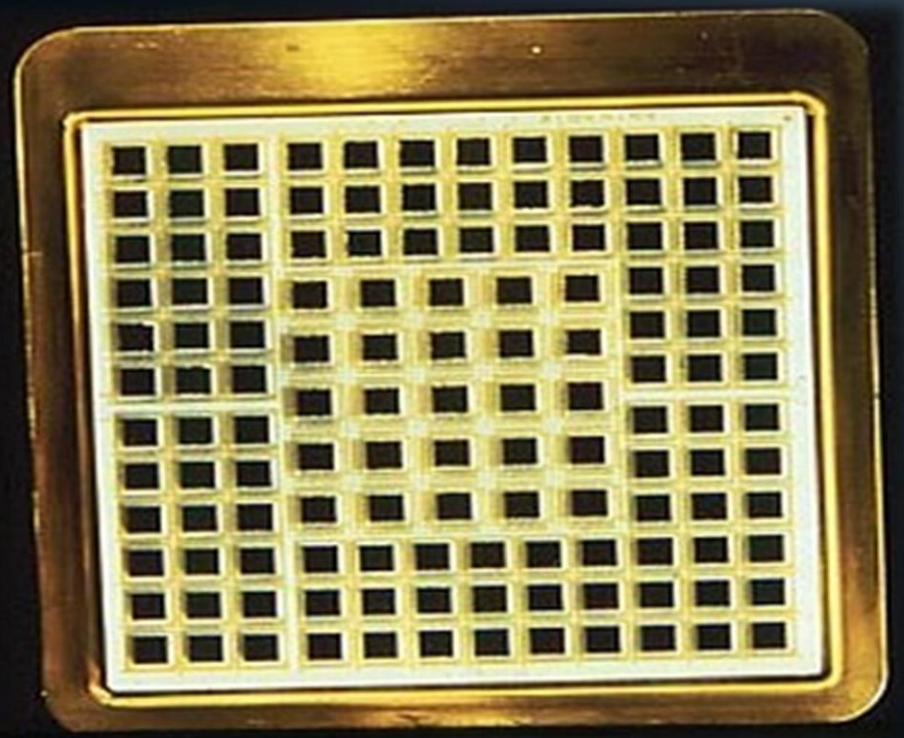
- Chip Size
- Chip Performance
- Packaging & Integration
- Chip Color
- Chip Taste

The Sweet Spot for Integration



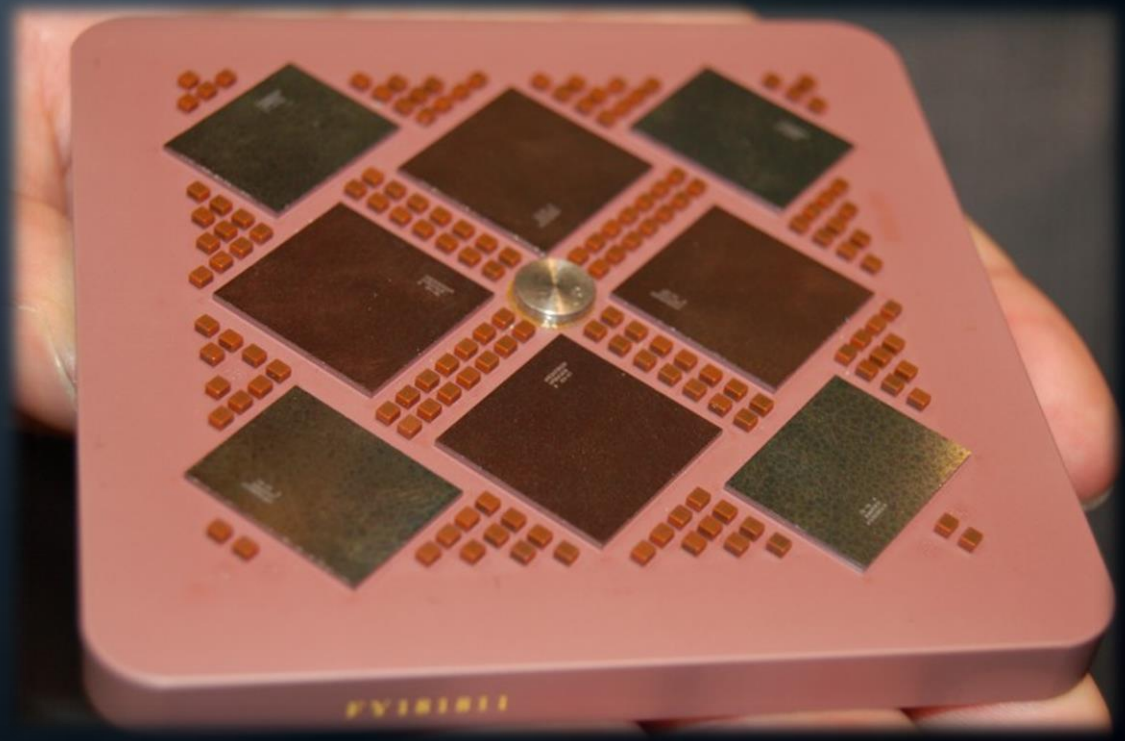
Is this new?

IBM 3081 Logic Module



Introduced in 1980

Google Search for “Multi-chip Module” (IBM Power 5)



Launched in 2004

Call to Action

- What does Packaging have to Deliver?
  - Do all the things the chip can't
    - Talk to the outside world
    - Integrate content that doesn't want to be on one piece of Silicon

- What do we (as Packaging Engineers) have to become Experts in?
  - Understand what products need
  - Translate what products need into package technology requirements
  - Execute Development and Know the Trade-offs

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