

INTEL® NON-VOLATILE MEMORY INSIDE. THE SPEED OF POSSIBILITY OUTSIDE.

Rob Crooke

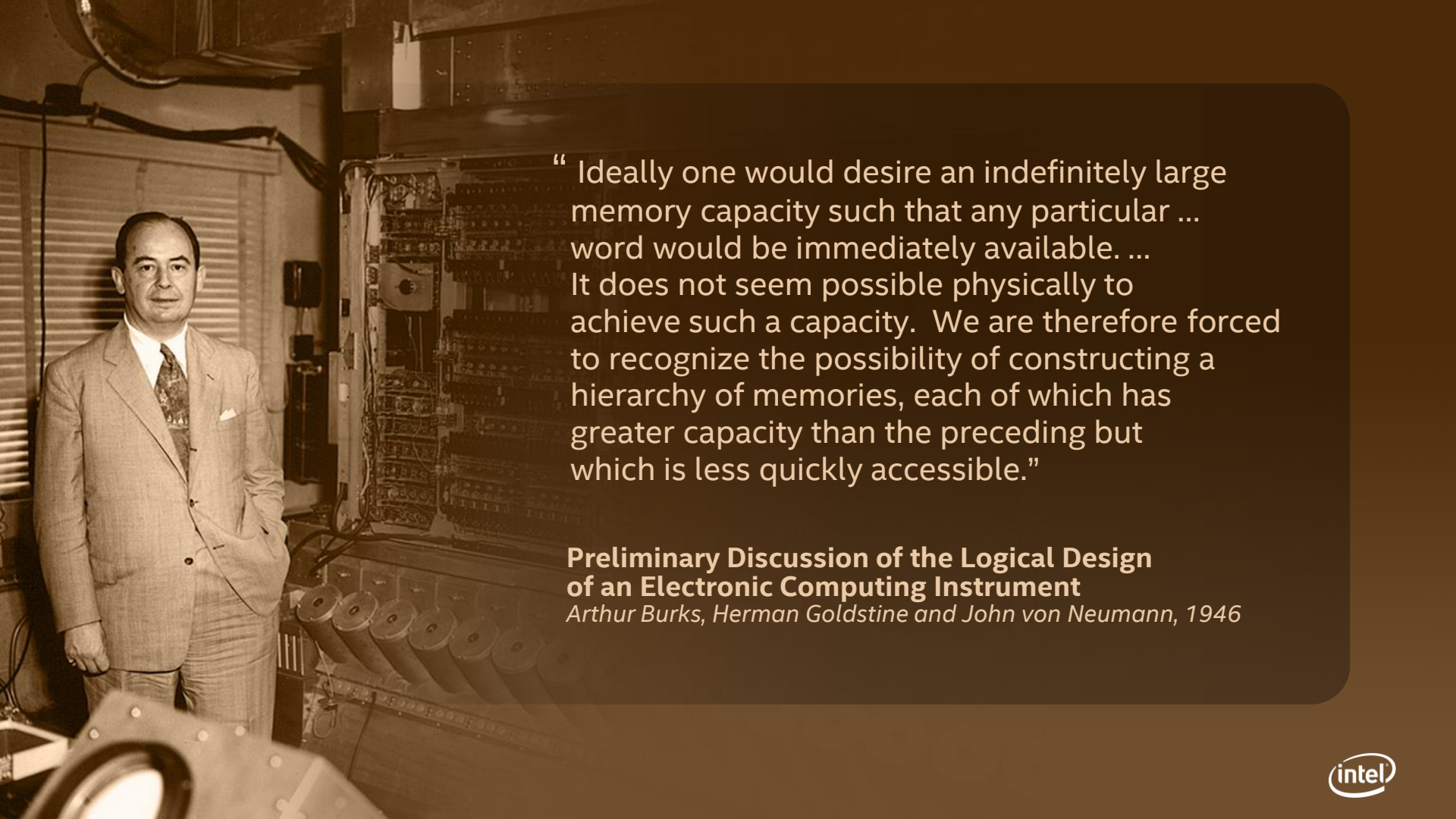
Senior Vice President
General Manager,
Non-Volatile Memory Solutions Group

Al Fazio

Senior Fellow, Technology
and Manufacturing Group
Director, Memory Technology Development



experience
what's inside™



“ Ideally one would desire an indefinitely large memory capacity such that any particular ... word would be immediately available. ... It does not seem possible physically to achieve such a capacity. We are therefore forced to recognize the possibility of constructing a hierarchy of memories, each of which has greater capacity than the preceding but which is less quickly accessible.”

**Preliminary Discussion of the Logical Design
of an Electronic Computing Instrument**

Arthur Burks, Herman Goldstine and John von Neumann, 1946



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**Preliminary Discussion of the Logical Design
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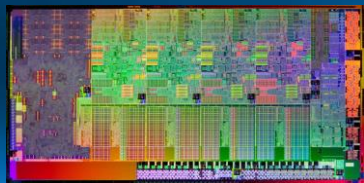
MEMORY AND STORAGE HIERARCHY

The Past 40 Years ...

The Performance Problem Grows Bigger Over Time

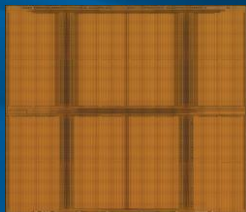
SRAM

Latency: 1X
Size of Data: 1X



DRAM

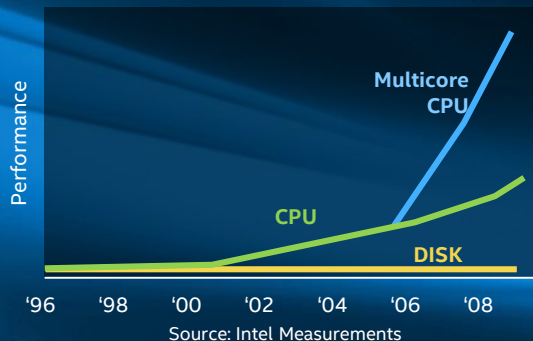
Latency: ~10X
Size of Data: ~100X



STORAGE

CPU PERFORMANCE

Normalized Media Access
Time for 20K Read



HDD

Latency: ~10 Million X
Size of Data: ~10,000X



MEMORY

Technology claims are based on comparisons of latency, density and write cycling metrics amongst memory technologies recorded on published specifications of in-market memory products against internal Intel specifications.



MEMORY AND STORAGE HIERARCHY

The Past 40 Years ...

NAND SSDs Help Alleviate The Gap In The Hierarchy

SRAM

Latency: 1X
Size of Data: 1X



DRAM

Latency: ~10X
Size of Data: ~100X



STORAGE

NAND SSD

Latency: ~100,000X
Size of Data: ~1,000X



HDD

Latency: ~10 MillionX
Size of Data: ~10,000X



MEMORY

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THE EXPLOSION OF DATA

*Requires Technology To Perform Random Data Access,
Low Queue Depth and Cache Line Size Optimally*

Many Industries Are Seeking the “Ideal Memory”

Financial Services



Fraud Detection



Online Advertising



Scientific Research



Gaming





INTEL AND MICRON BRING
A NEW CLASS OF STORAGE AND MEMORY

3D XPoint™

TECHNOLOGY



3D XPOINT™ TECHNOLOGY

In Pursuit of Large Memory Capacity ... Word Access ... Immediately Available ...

Word (Cache Line)

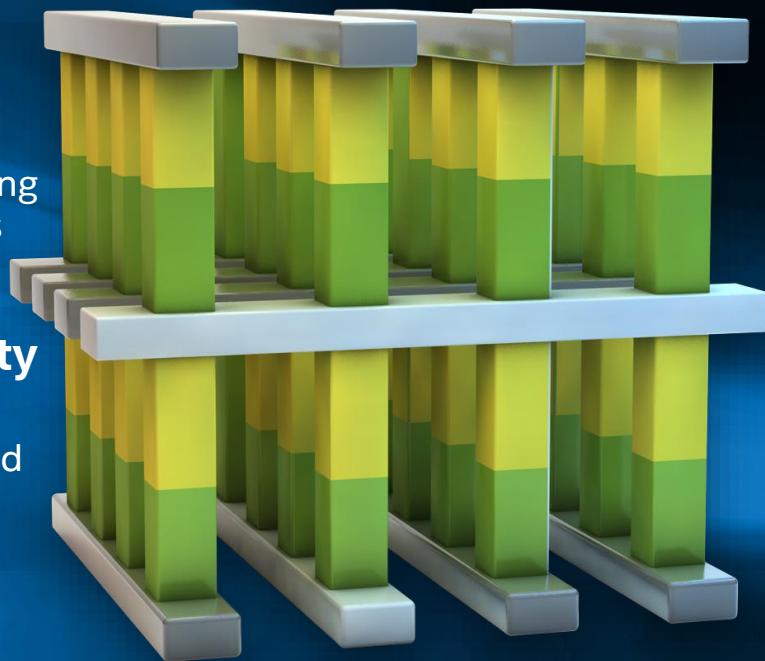
Crosspoint Structure

Selectors allow dense packing and individual access to bits

Large Memory Capacity

Crosspoint & Scalable

Memory layers can be stacked in a 3D manner



NVM Breakthrough Material Advances

Compatible switch and memory cell materials

Immediately Available

High Performance Cell and array architecture that can switch states 1000x faster than NAND



3D XPoint™ TECHNOLOGY

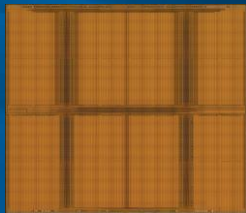
SRAM

Latency: 1X
Size of Data: 1X



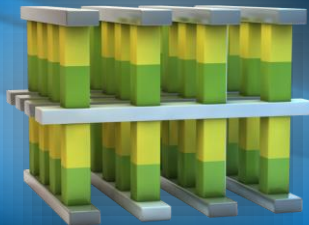
DRAM

Latency: ~10X
Size of Data: ~100X



3D XPoint™

Latency: ~100X
Size of Data: ~1,000X



STORAGE

NAND

Latency: ~100,000X
Size of Data: ~1,000X



HDD

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3D XPoint™ TECHNOLOGY

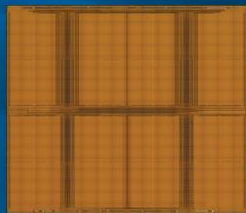
SRAM

Latency: 1X
Size of Data: 1X



DRAM

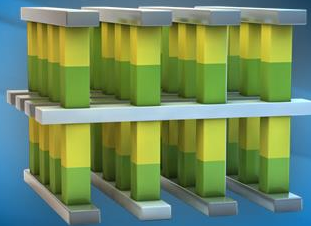
Latency: ~10X
Size of Data: ~100X



STORAGE

3D XPoint™

Latency: ~100X
Size of Data: ~1,000X



MEMORY

NAND

Latency: ~100,000X
Size of Data: ~1,000X



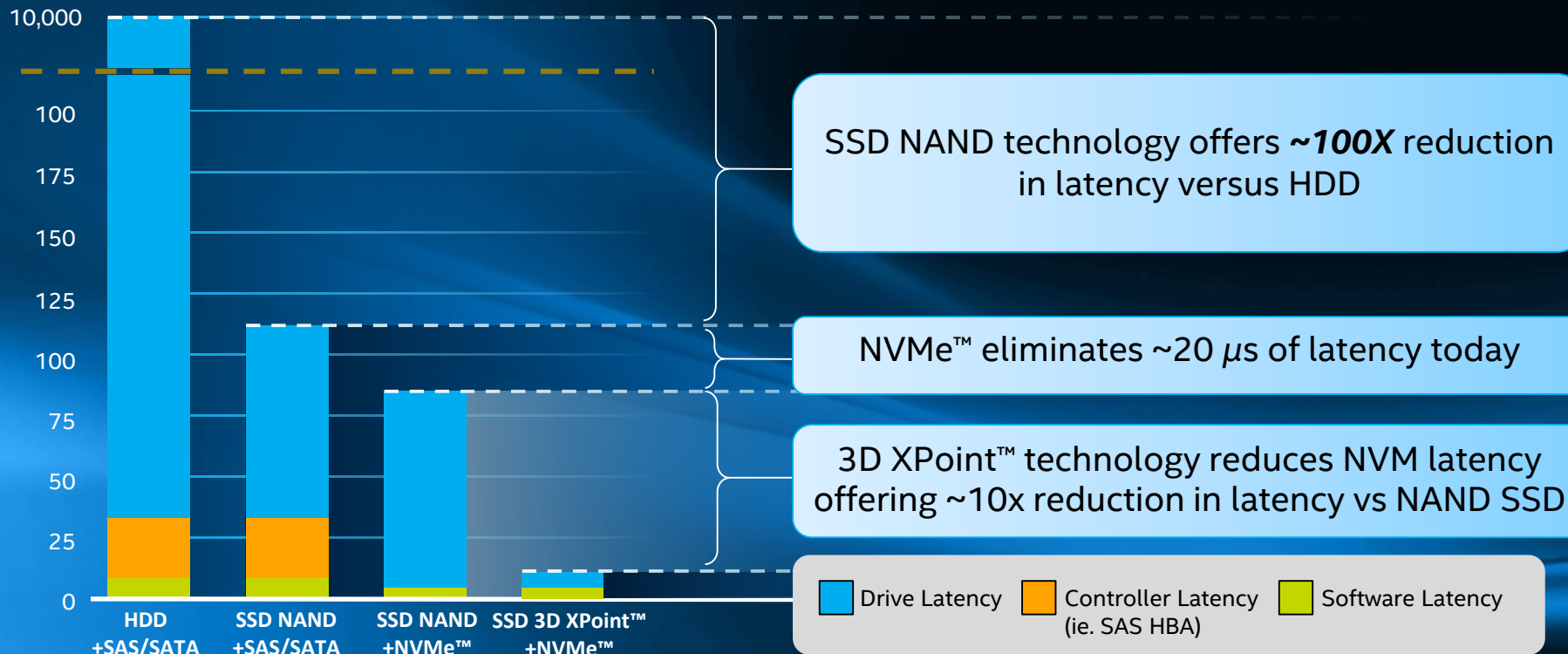
HDD

Latency: ~10 MillionX
Size of Data: ~10,000 X



NVMe WITH 3D XPoINT™ TECHNOLOGY

Latency (uS)



Source: Storage Technologies Group, Intel

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INTEL® OPTANE™ TECHNOLOGY

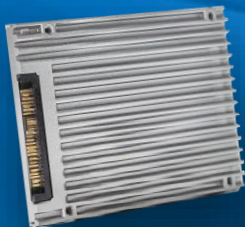
*All SSD Form Factors
Based on 3D XPoint™ Memory*



Add-In Card



M.2



U.2 2.5in.

GAMING EXAMPLE

NVMe™ SSDs With Optane™ Technology Deliver
an Immersive, Truly Open World With
Uninterrupted Game Play

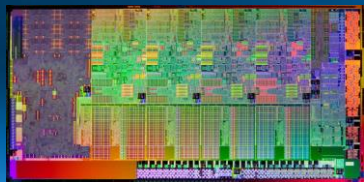


3D XPoint™ TECHNOLOGY

Breaks The Memory Storage Barrier

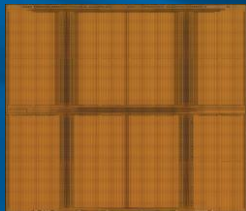
SRAM

Latency: 1X
Size of Data: 1X



DRAM

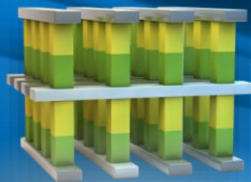
Latency: ~10X
Size of Data: ~100X



STORAGE

3D XPoint™

Latency: ~100X
Size of Data: ~1,000X



NAND SSD

Latency: ~100,000X
Size of Data: ~1,000X



HDD

Latency: ~10 MillionX
Size of Data: ~10,000X



MEMORY

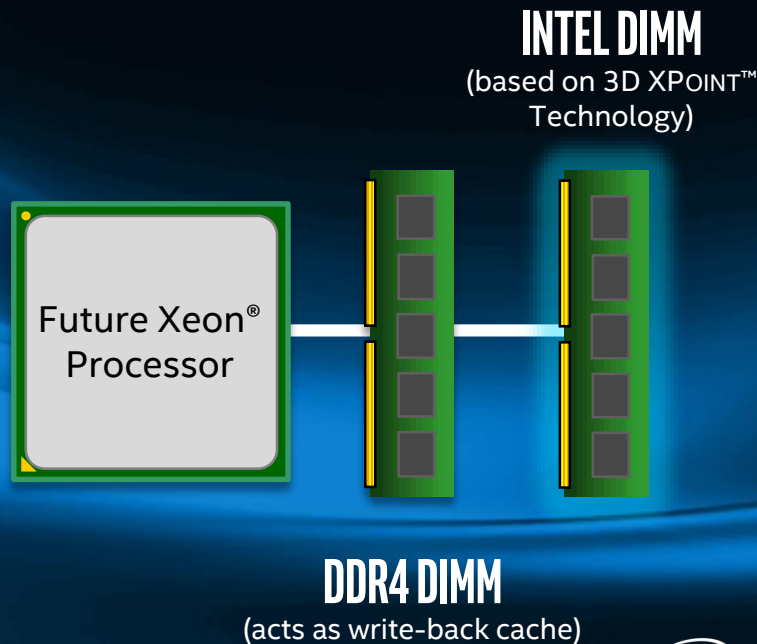
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INTEL DIMMs

Based on 3D XPoint™ Technology

- DDR4 electrical & physical compatible
- Supported on next generation Intel® Xeon® platform
- Up to 4X system memory capacity, at significantly lower cost than DRAM
- Can deliver big memory benefits without modifications to OS or applications





3D XPOINT™ TECHNOLOGY

WHAT WILL YOU DO WITH IT?

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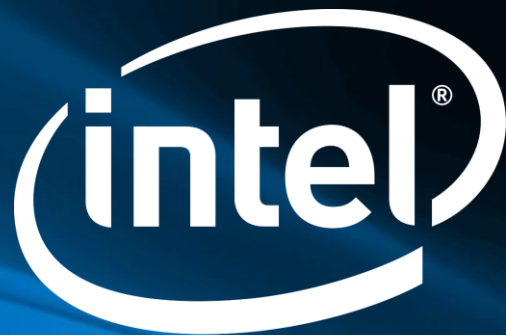
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experience
what's inside™