Data Storage and Personal Entertainment

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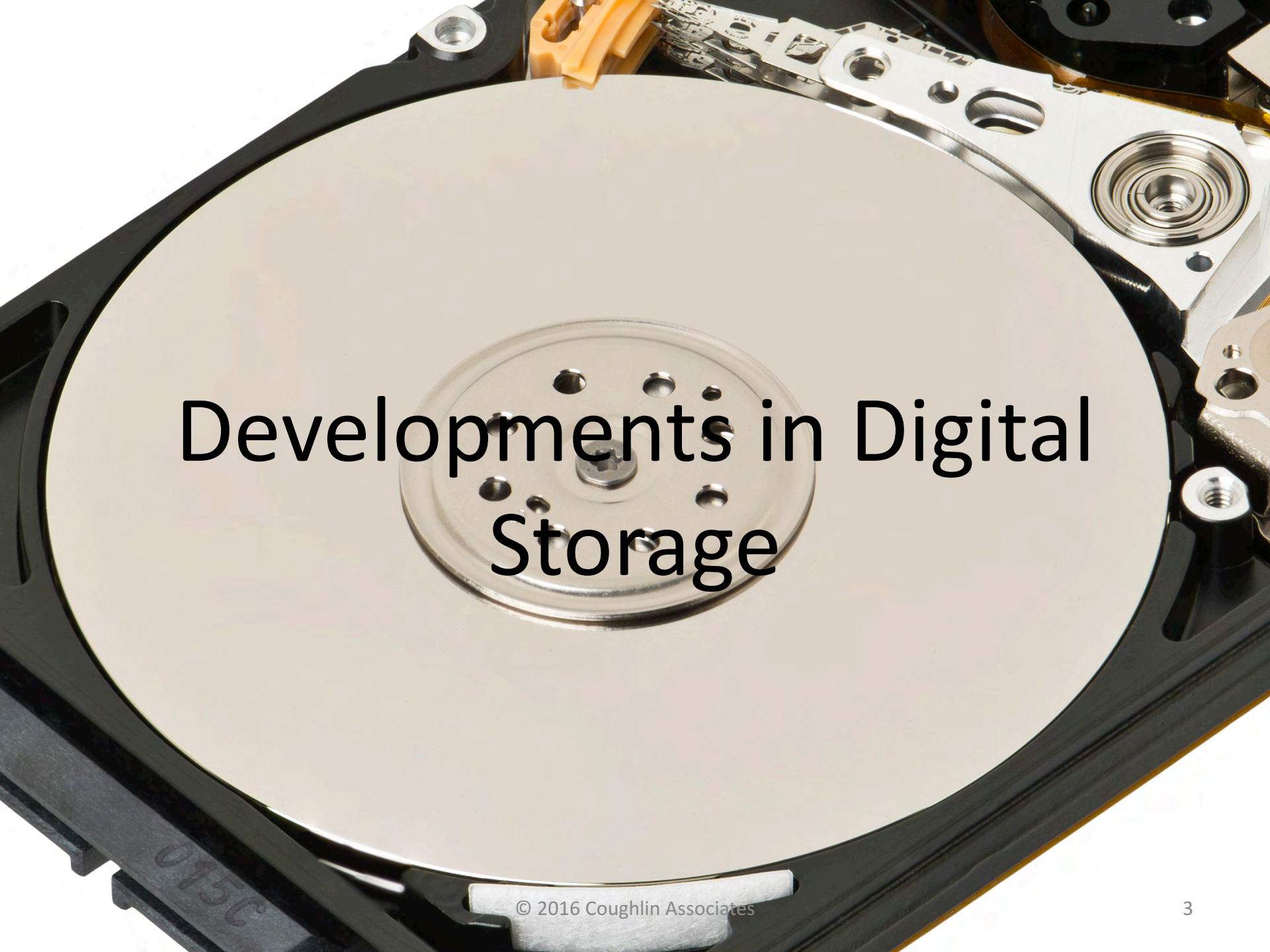www.tomcoughlin.com

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Outline

- Developments in Storage Technology
- Developments in Personal Entertainment
  - Interfaces
  - VR/AR
- Internet of Things and Personal Entertainment
- In the Cloud, the local network or the local device?
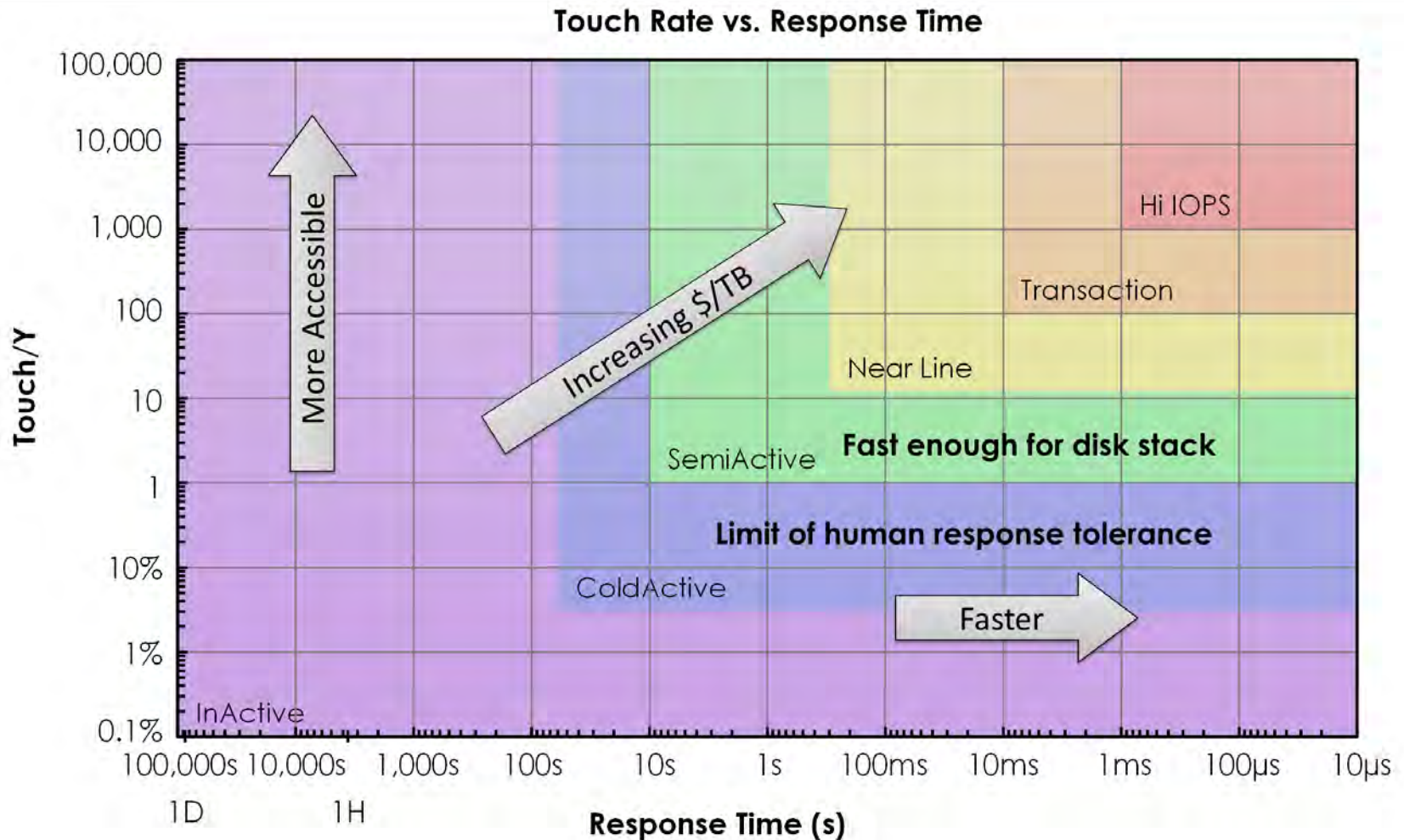- Conclusions
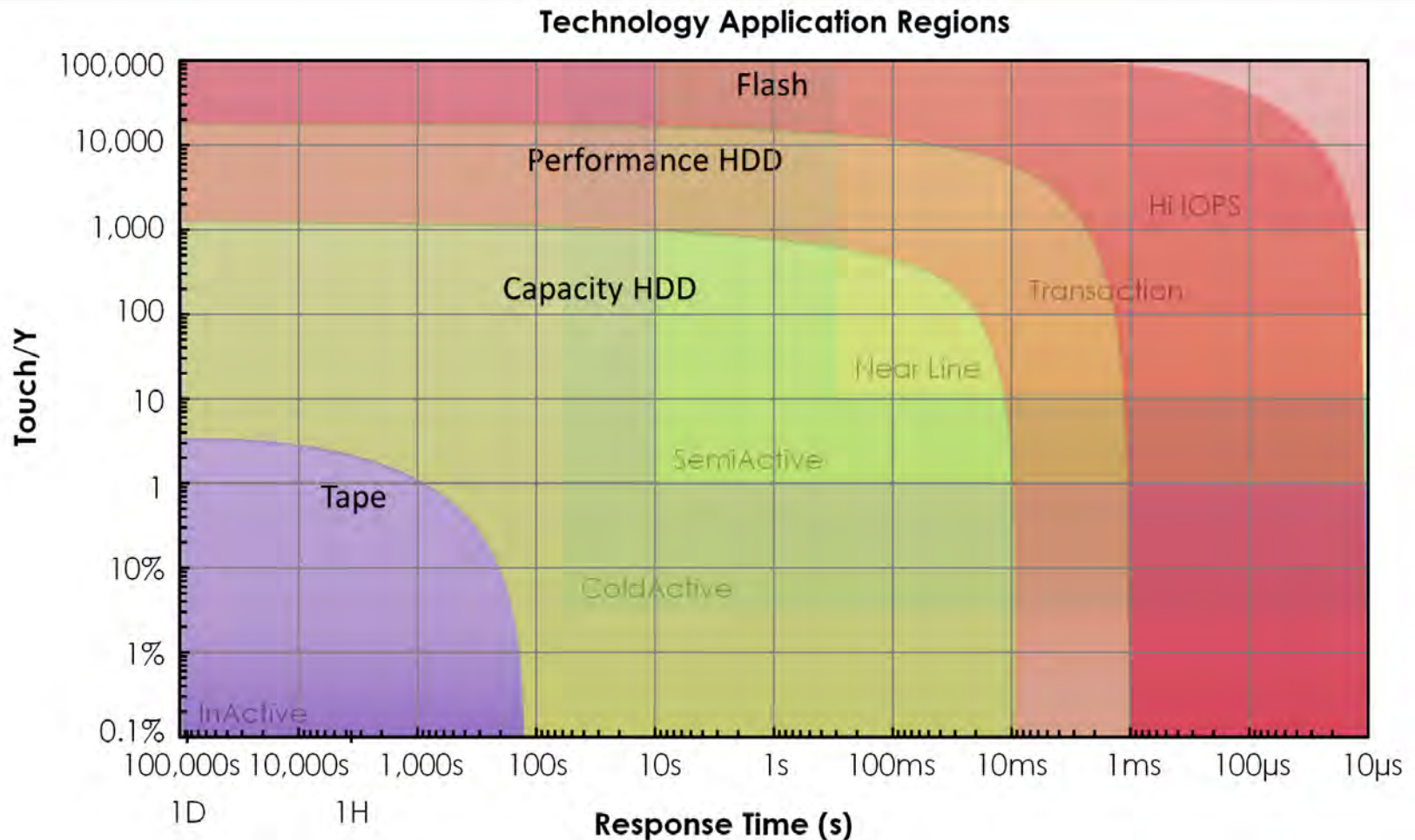
Developments in Digital Storage

Storage Devices

- Hard Disk Drives
- Optical Disks
- Flash Memory
- Emerging Solid State Memory Technologies

Touch rate versus response time indicating various types of uses

Touch Rate vs. Response Time

Digital storage technologies regions overlaid on the Touch Rate/Response Time chart
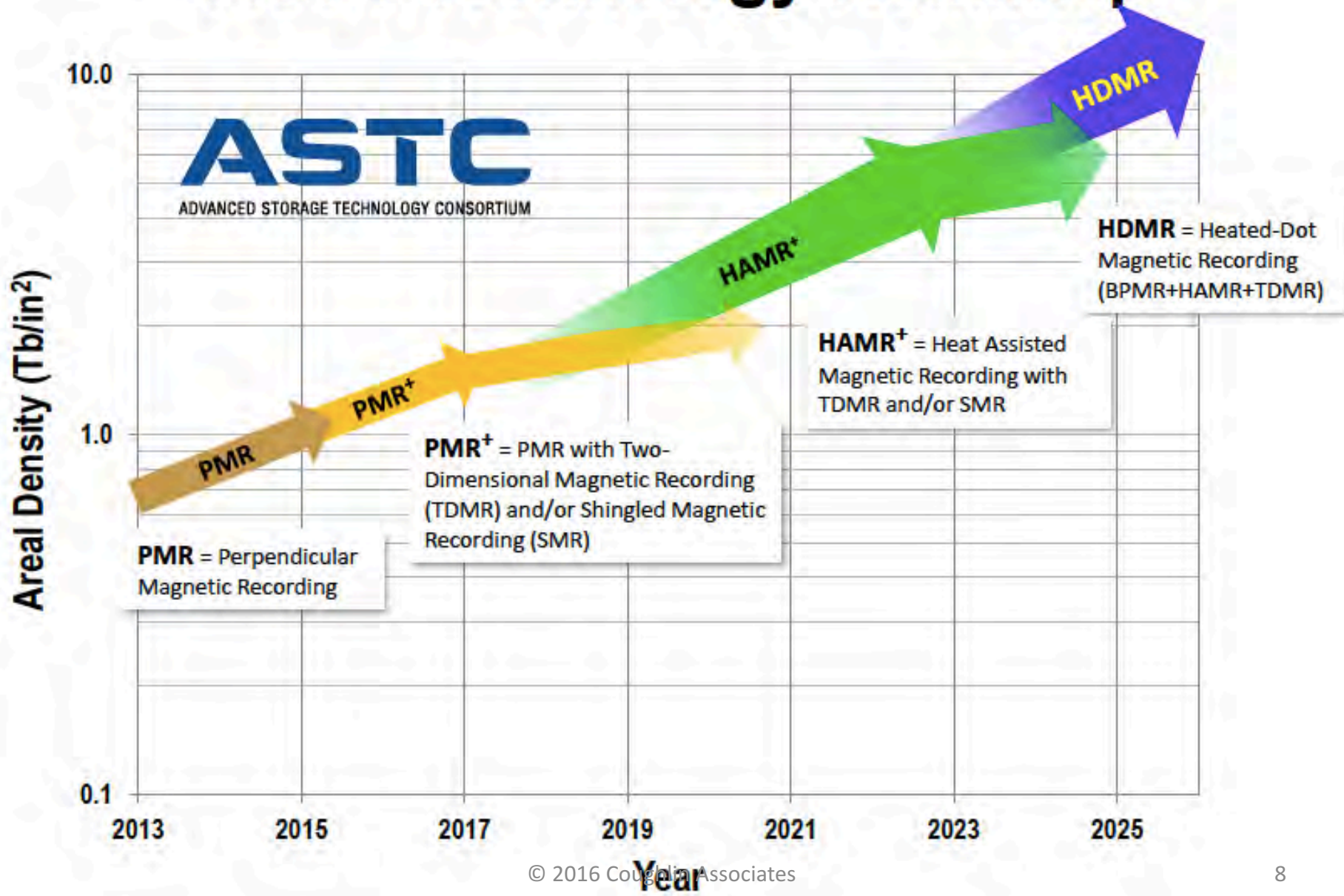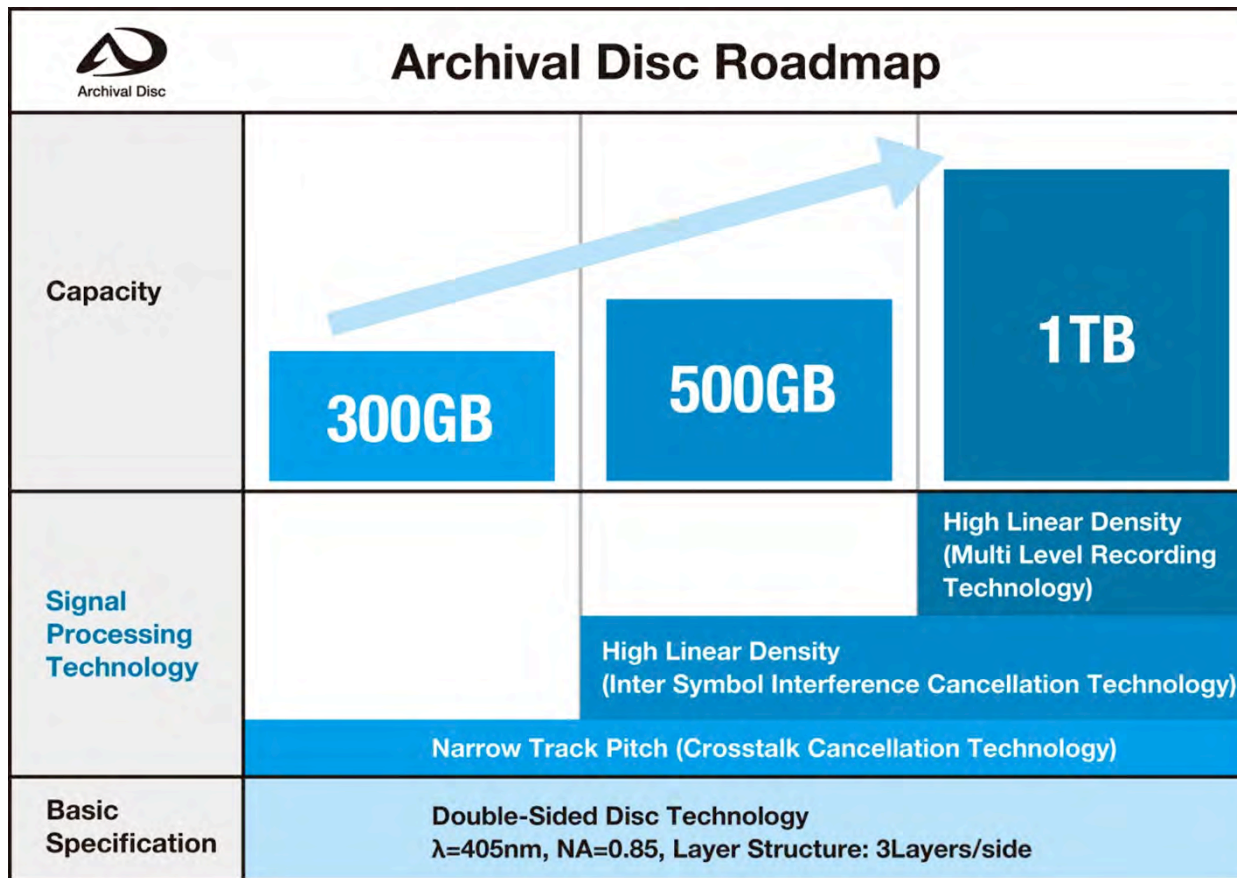
Hard disk drives

- Hard disk drives used in PCs, game consoles, DVRs, external storage, and in data centers

- HDD storage in the data centers is the biggest element in Cloud Storage

- New Developments
  - Up to 10 TB He-filled HDDs
  - USB 3.0 powered 3.5-inch HDDs
  - Areal densities up to 1.3 Tbpsi

ASTC Technology Roadmap

HDMR = Heated-Dot Magnetic Recording (BPMR+HAMR+TDMR)

HAMR⁺ = Heat Assisted Magnetic Recording with TDMR and/or SMR

PMR⁺ = PMR with Two-Dimensional Magnetic Recording (TDMR) and/or Shingled Magnetic Recording (SMR)

PMR = Perpendicular Magnetic Recording

Optical storage

Archival Disc Roadmap

|			
Capacity	300GB	500GB	1TB
Signal Processing Technology			High Linear Density (Multi Level Recording Technology)
		High Linear Density (Inter Symbol Interference Cancellation Technology)	
	Narrow Track Pitch (Crosstalk Cancellation Technology)		
Basic Specification	Double-Sided Disc Technology λ=405nm, NA=0.85, Layer Structure: 3Layers/side		

- Optical discs for content distribution decreasing in popularity—some growth in Blu-ray discs for home use
- Push for write-once optical in archiving applications
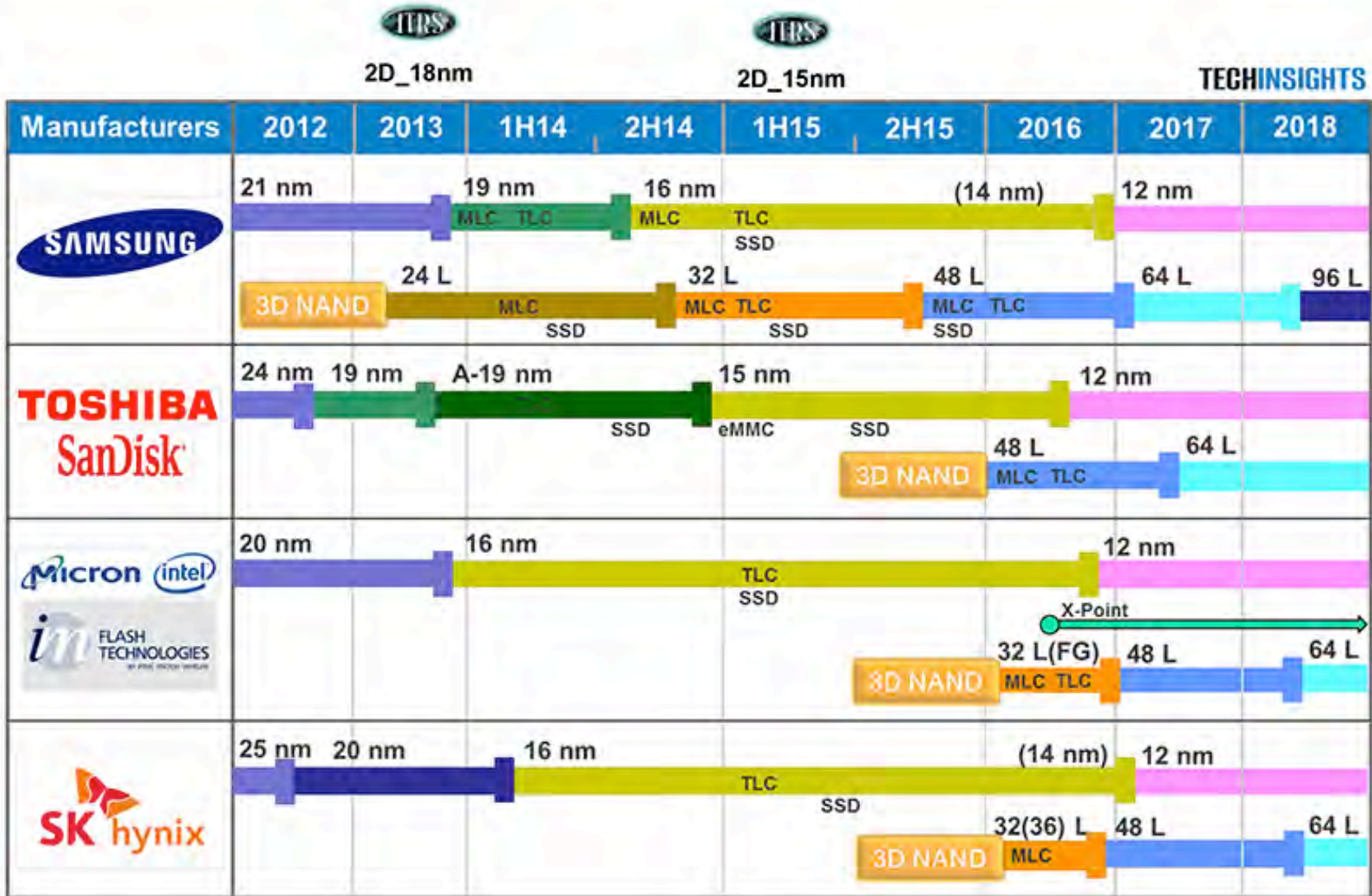- Facebook, among others using optical discs in their data centers
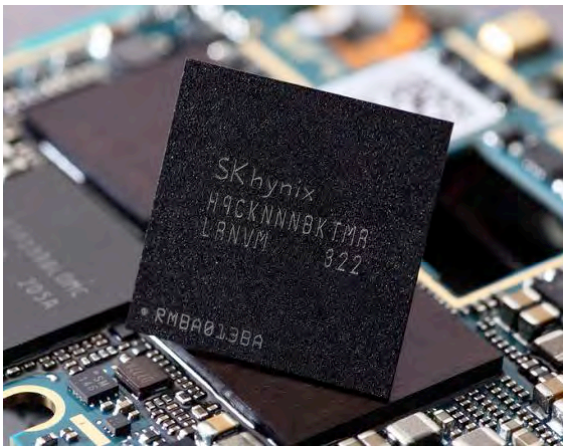
Flash memory

- Flash memory is very popular in mobile devices for internal local storage—e.g. smart phones, watches and tablet computers

- Flash is also in an increasing number of mobile PCs

- Flash cards, USB sticks and external SSDs
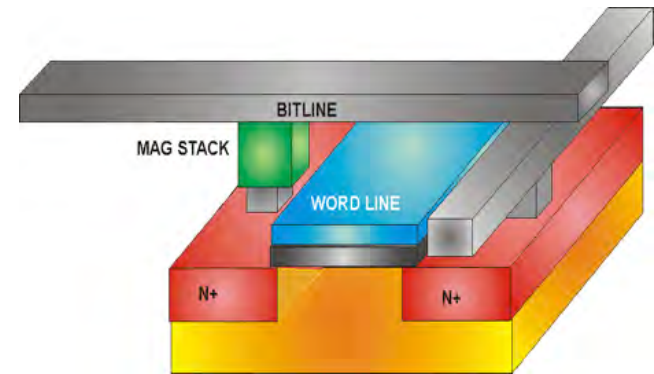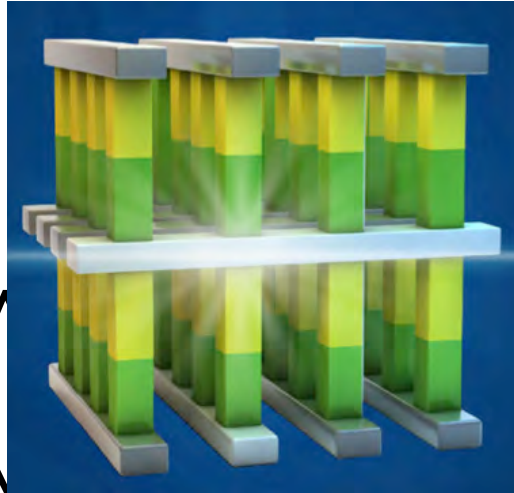 - E.g. 500 GB Samsung external flash drive

Flash memory roadmap

2016 emerging memory market

- 3D XPoint and ReRAM products
- Growth in STT-MRAM
- NVM will save pov enable instant-on
- Persistent memory enables memory sharing (RDMA)
- In-situ processing

Emerging NVM market could exceed $2 B by 2020

2015 Emerging Non-Volatile Memory & Spin Logic Technologies and Manufacturing Report, Coughlin Associates, ,
http://www.tomcoughlin.com/techpapers.htm

Developments in Personal Entertainment

Expanding options for personal entertainment

- Today's personal entertainment devices include smart phones and tablets
- In the future they may include watches, rings and perhaps head mounted display devices (for VR or AR)
- These devices have significant processing power and memory to hold many pieces of content
- These devices may also communicate with each other using e.g. Bluetooth radio connections
- These devices, associated with a customer, constitute that customer's digital local environment (possibly part of a fog or edge network)
- What they generally don't have is power to supply enough energy for the device to provide active entertainment over several hours.

Smart phones and tablets

- In 2016 a typical mobile phone has 16 GB of storage, but storage up to 128 GB is available

- In 2016 32 GB tablets are common but up to 256 GB are available

- The resolution of these devices are increasing, HD and even 4K displays are becoming common

- The move to head mounted VR devices using phones will increase demand for resolution, event to 8K resolution.

CE device storage interfaces

- USB 3.1, Gen 2 = 10Gb/s
- Unique power delivery feature allows up to 100 W to external devices
- USB-C physical interface has no wrong way to insert it
- Thunderbolt 3, working off the PCIe bus runs bidirectional at 20 Gb/s over the USB-C interface
- NVMe interface runs on PCIe and used in new SSDs (e.g. M.2) and also may be used as a network fabric

Virtual reality

- Virtual reality goes beyond simple 3D content to surround an individual user with a different environment

- The most popular approaches use smart phones

- There are also solutions for stereoscopic interaction with content without a headset

INTERNET *of* THINGS

The internet of things (IoT)

- Interconnected intelligent devices (things) are all the rage in technology circles.

  - As the price declines and the availability of microprocessors increases, they are showing up in consumer products ranging from thermostats to refrigerators.

- The convergence of ubiquitous processing and networking is often referred to as the Internet of Things (IoT). As a result of the proliferation of smart connected devices, smart things will be in our homes, our factories, our gardens and in the air.

IoT driving consumer and industrial applications

- Connected-home device shipments will grow at a compound annual rate of 67% over the next 5 years..and hit 1.8 billion units shipped in 2019 – BI Intelligence

Category	2013	2014	2015	2020
Automotive	96.0	189.6	372.3	3,511.1
Consumer	1,842.1	2,244.5	2,874.9	13,172.5
Generic Business	395.2	479.4	623.9	5,158.6
Vertical Business	698.7	836.5	1,009.4	3,164.4
Grand Total	3,032.0	3,750.0	4,880.6	25,006.6

Internet of Things installed base by category (M of units),
Source: Garner, Nov. 2014

What sort of consumer devices will be in the IoT

- Home appliances
- Cars
- Tablets and Smart Phones
- Wearable devices
- Internal medical devices
- Just about everything you can think of

In the Cloud, the Local Network or the Local Device?
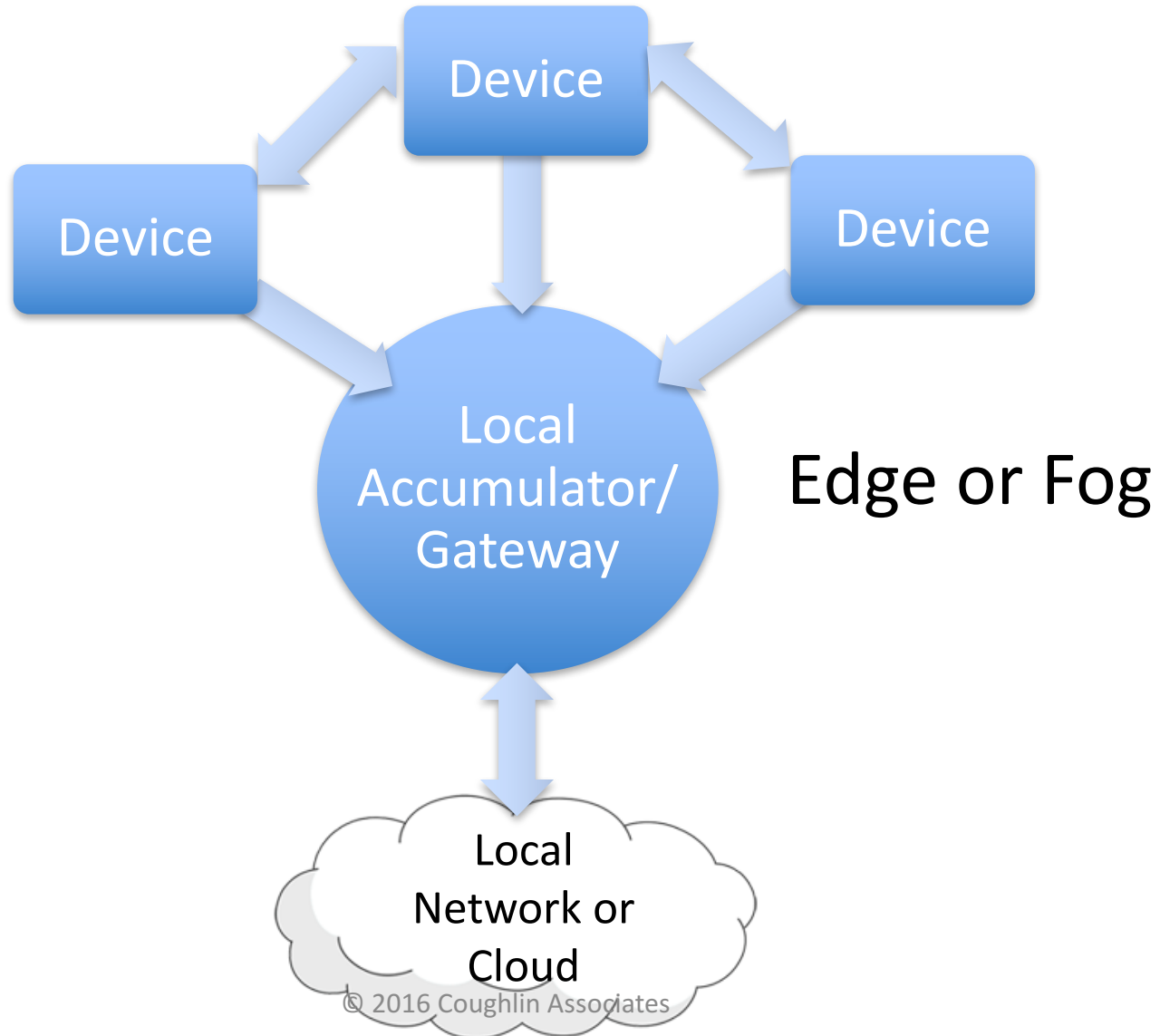
Balancing Storage

- Even if content is streaming from an external source (local network or the cloud) it still needs some local cache storage to deal with network latency and other issues

- If there are lot of things communicating and exchanging information in a local network there may be a need for local network storage

- Because of latency and connectivity issues (particularly in airplanes), content may be kept in a cloud library and downloaded to the local network or individual device storage but likely cannot be streamed directly from the cloud

- So a local network DVR generally makes more sense that cloud-based network DVR

Example of Network VPR VOD System
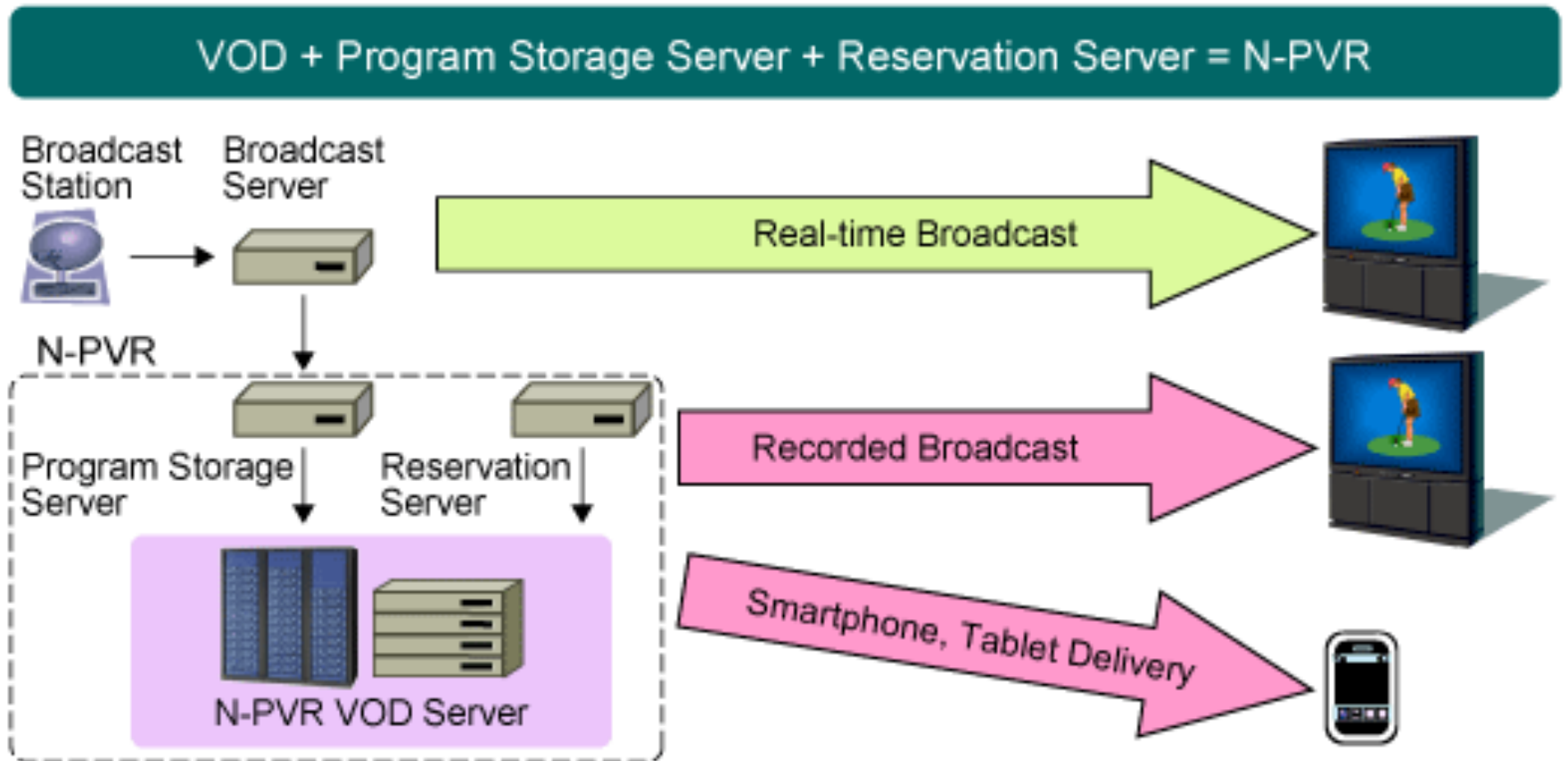
From Oki Media Server Web Page, https://oki.com/en/streaming/product/index.html

Personal Devices Communicate with Local Gateway and Local Network or the Cloud

Device

Device

Device

Local Accumulator/ Gateway

Edge or Fog

Local Network or Cloud

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Conclusions

- Digital storage technology is developing providing more storage at a lower price and higher performance

- Personal entertainment devices has more storage capacity and higher resolution content requirements

- Likely customers will use their own devices and/or the plane screens for their entertainment—remember they have limited power

- New factors include VR/AR and the IoT

- Likely storage needed in the local network as well as personal devices to support customer's personal digital environments

References

- <u>The Internet of Things Meets the Storage of Everything</u>, Tom Coughlin, Consumer Electronics Magazine, April 2015, pp. 118-120
- Touch Rate: A metric for analyzing storage system performance, Steven Heltzer and Tom Coughlin, 2015, http://www.tomcoughlin.com/techpapers.htm
- **2015 Emerging Non-Volatile Memory & Spin Logic Technologies and Manufacturing Report,** Coughlin Associates, , http://www.tomcoughlin.com/techpapers.htm

Thanks