Data Storage and Personal Entertainment

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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
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 Tbps
ASTC Technology Roadmap

**PMR = Perpendicular Magnetic Recording**

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

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

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

- 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 power, enable instant-on
- Persistent memory enables memory sharing (RDMA)
- In-situ processing

Emerging NVM market could exceed $2 B by 2020


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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
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.

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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

<table>
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</tbody>
</table>

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

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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

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

Local Accumulator/Gateway

Edge or Fog
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

• The Internet of Things Meets the Storage of Everything, 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

Thanks