facebook

Efficiency at Scale

Sanjeev Kumar
Director of Engineering, Facebook

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Agenda

1. Overview
2. Datacenter Architecture
3. Case Study: Optimizing BLOB Storage system
4. Questions

Facebook Stats

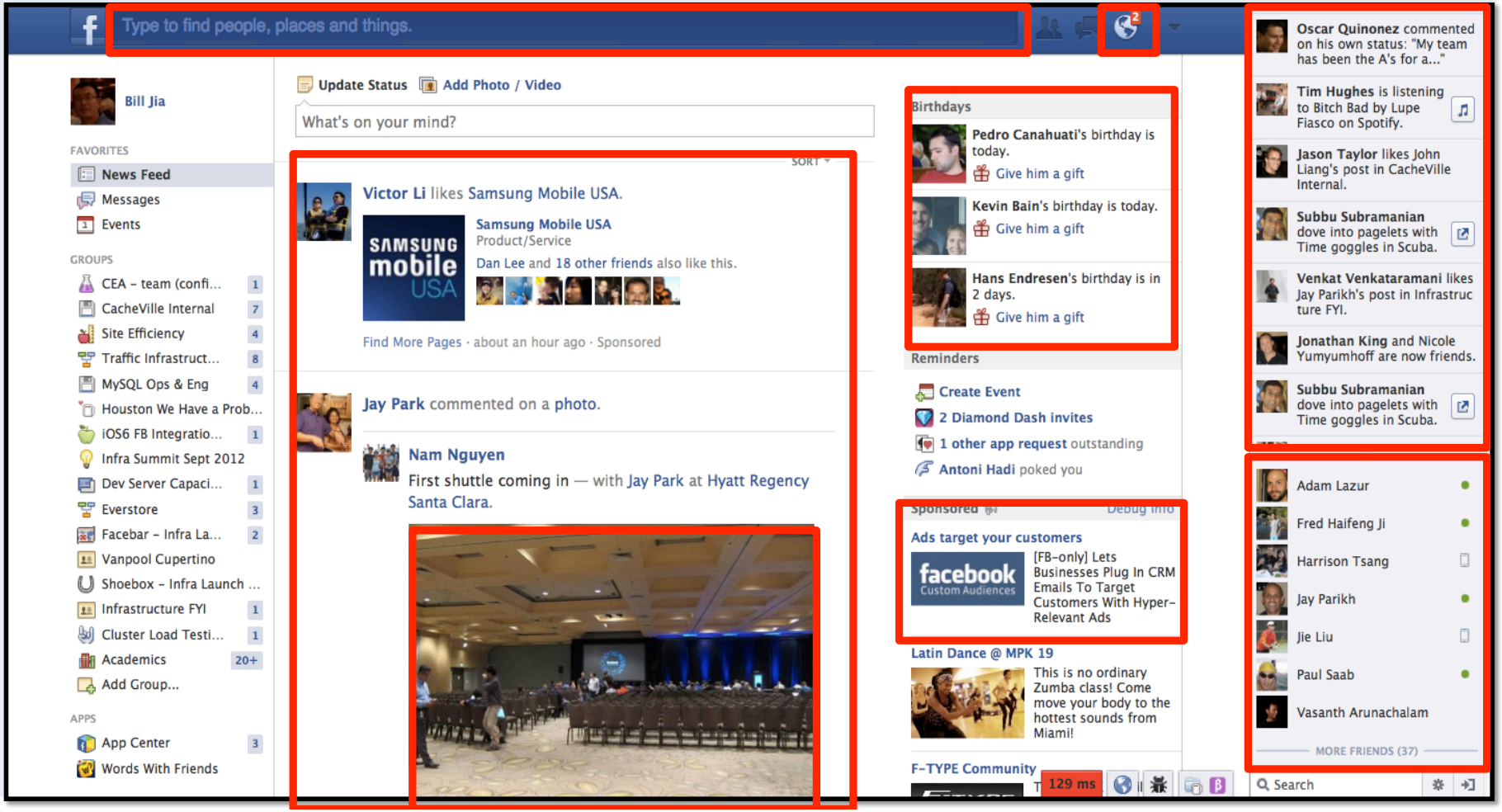
- 1.15 billion users **[6/2013]**
- ~700 million people use facebook daily

- 350+ million photos added per day **[1/2013]**
- 240+ billion photos

- 4.5 billion likes, posts and comments per day **[5/2013]**


Facebook Datacenter Regions
A large and growing server footprint

Services Provided by Facebook



Salient Points

- Efficiency matters
- Complex Software Stack
  - 1000+ specialized services to run
    - A few large services ✚ Long tail
- Custom hardware: cost of designing, validating, fixing
- Number of machines a service needs can change quickly

Many sources of complexity
Simplify as much as possible

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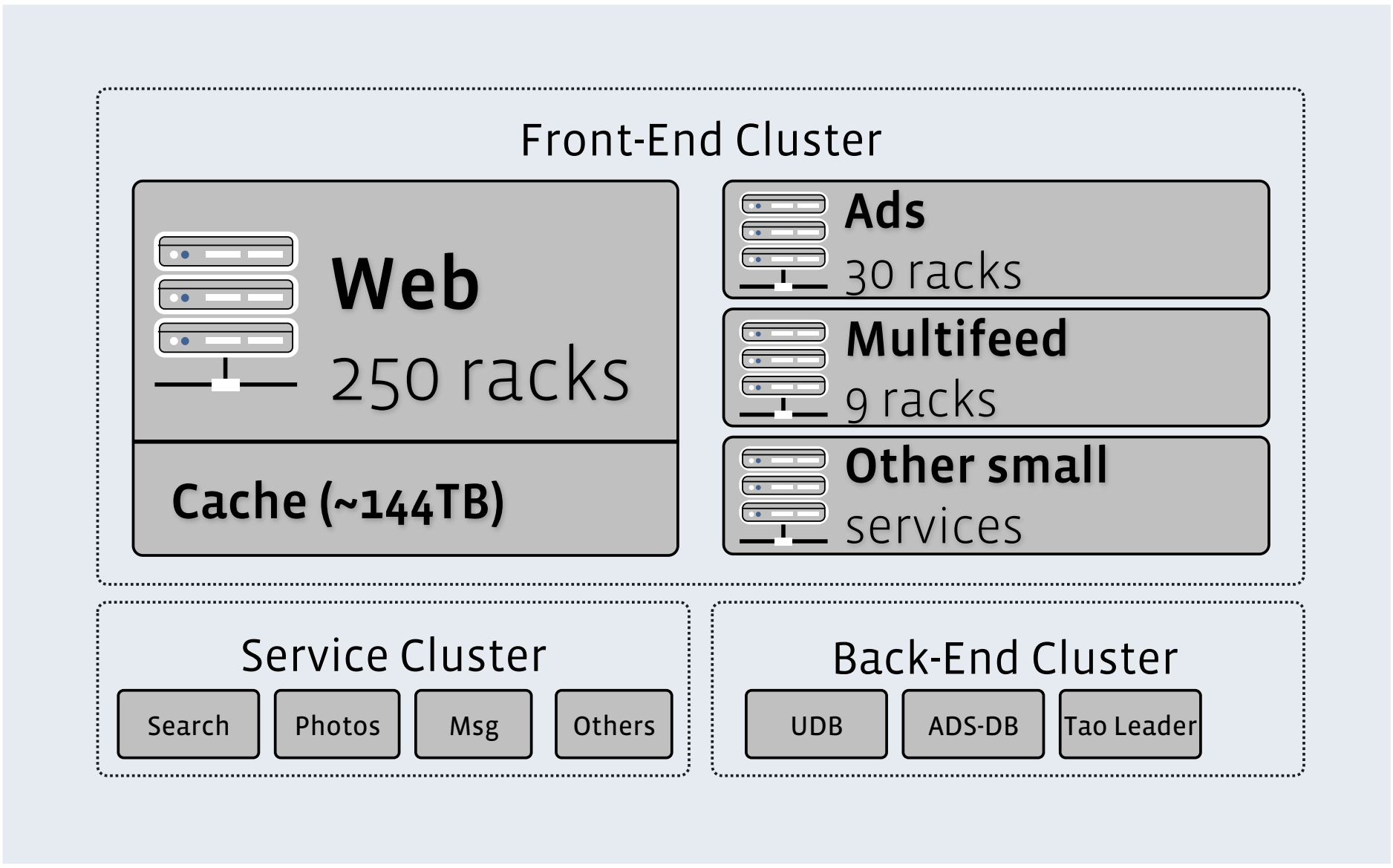
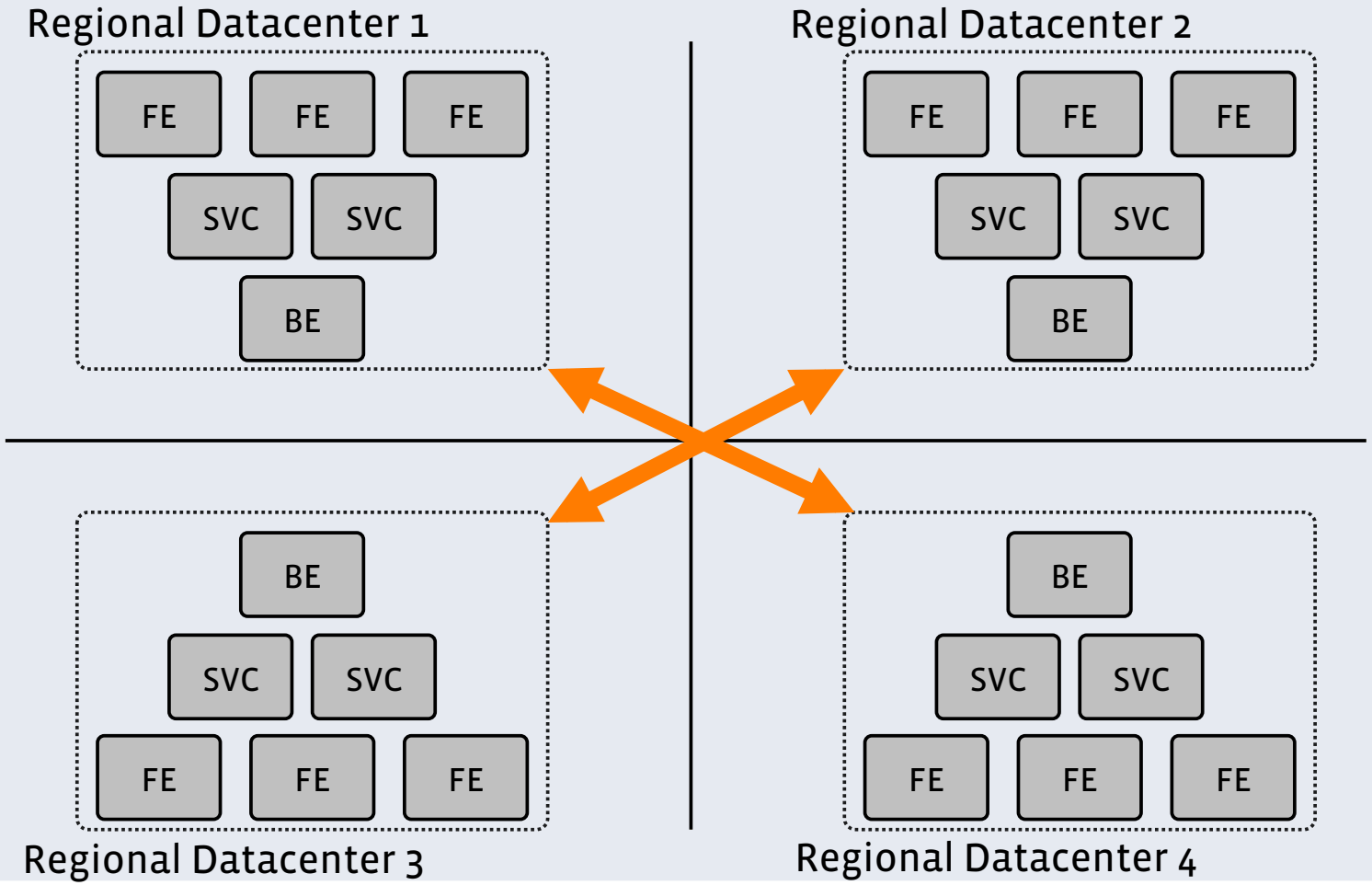

Front-End Cluster
Web
250 racks
Cache (~144TB)
Ads
30 racks
Multifeed
9 racks
Other small
services
Service Cluster
Search
Photos
Msg
Others
Back-End Cluster
UDB
ADS-DB
Tao Leader

Infrastructure Redundancy



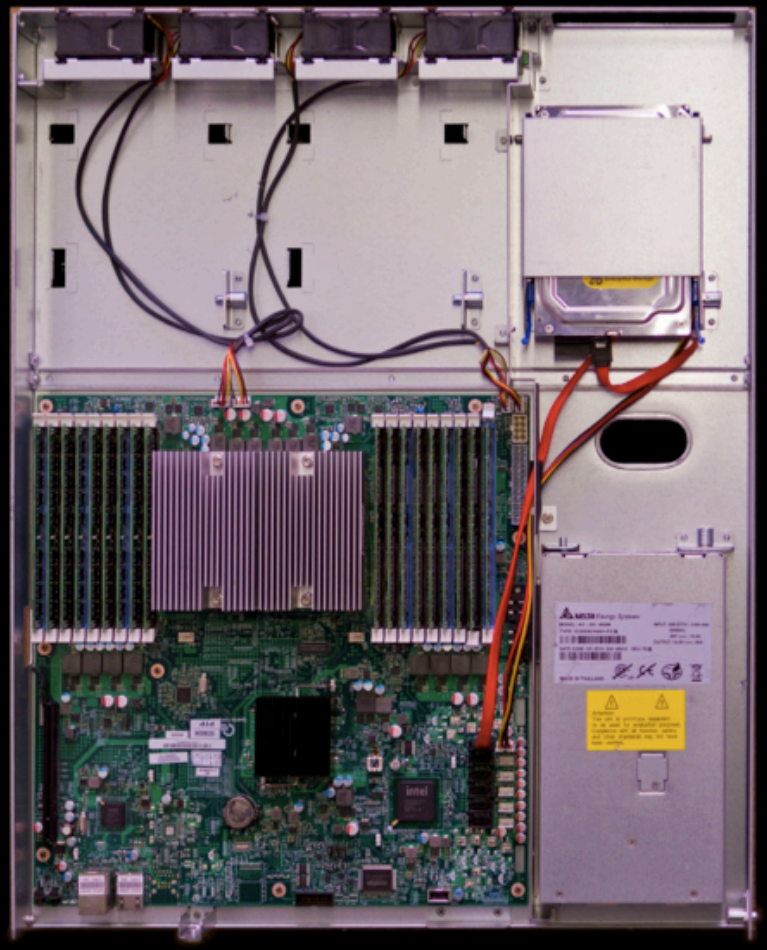
Standard Systems	Type I	Type II	Type III	Type IV	Type V	Type VI
CPU	High 2 x EN2670	Low 1 x 6128HE (AMD)	Medium 2 x X5650	Medium 2 x X5650	Low 1 x L5630	High 2 x EN2660
Memory	Low 16GB	High 144GB	High 144GB	Medium 48GB	Low 18GB	High 144GB
Disk	Low 250GB	Low 250GB	High IOP 6 x 600GB SAS +2x1.3TB Flash	High 12 x 3TB SATA	High 12 x 3TB SATA	Medium 1TB SATA
Services	Web, Chat, Ads	Memcache, Ads	Database	Hadoop	Photos, Video	Multifeed, Search

Standard Systems	Type I	Type II	Type III	Type IV	Type V	Type VI
CPU	High	Low	Medium	Medium	Low	High
Memory	Low	High	High	Medium	Low	High
Disk	Low	Low	High IOPs	High	High	Medium
Services	Web, Chat, Ads	Memcache, Ads	Database	Hadoop	Photos, Video	Multifeed, Search

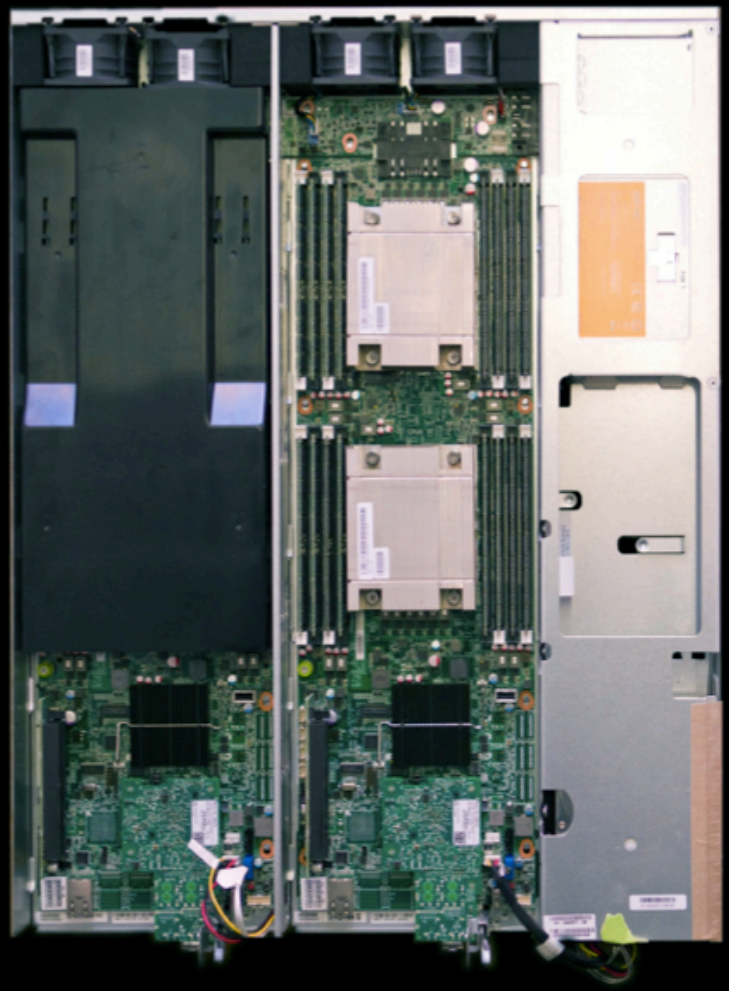
Server Generations

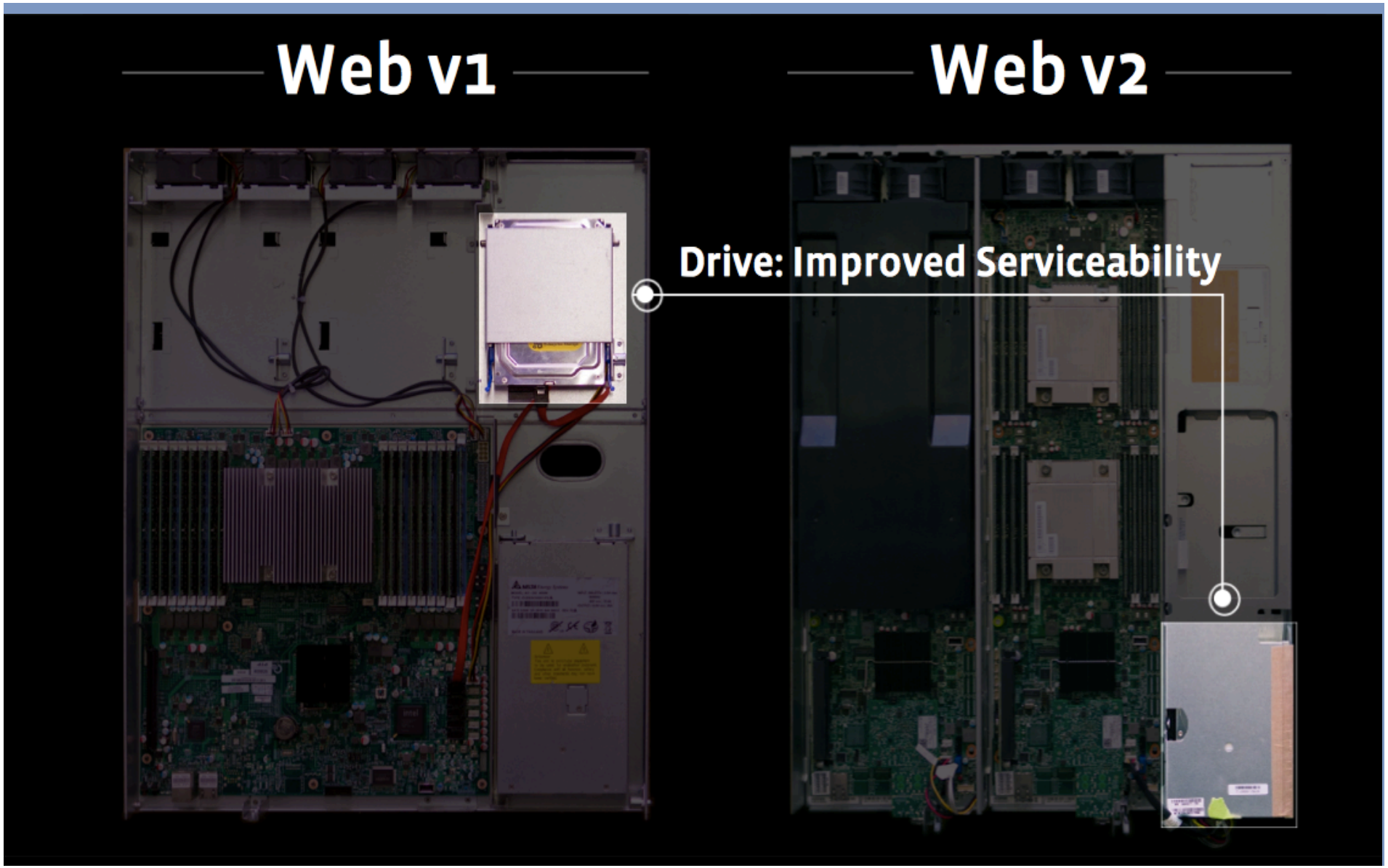
Web Servers	2008	2009	2010	2011	2012
Rack Composition	L5420 (SC)	L5520 (NHM)	L5639 (WSM)	X5650 (XWSM)	EN2670 (SND)
Cores / Speed	8 real cores 2.50 GHz	16 logical CPUs (HT) 2.27 GHz	24 logical CPUs (HT) 2.13 GHz	24 logical CPUs (HT) 2.67 GHz	32 Logical CPUs (HT) 2.33GHz
RCUs	0.6	1	1.4	1.75	2.41

Web v1



Web v2

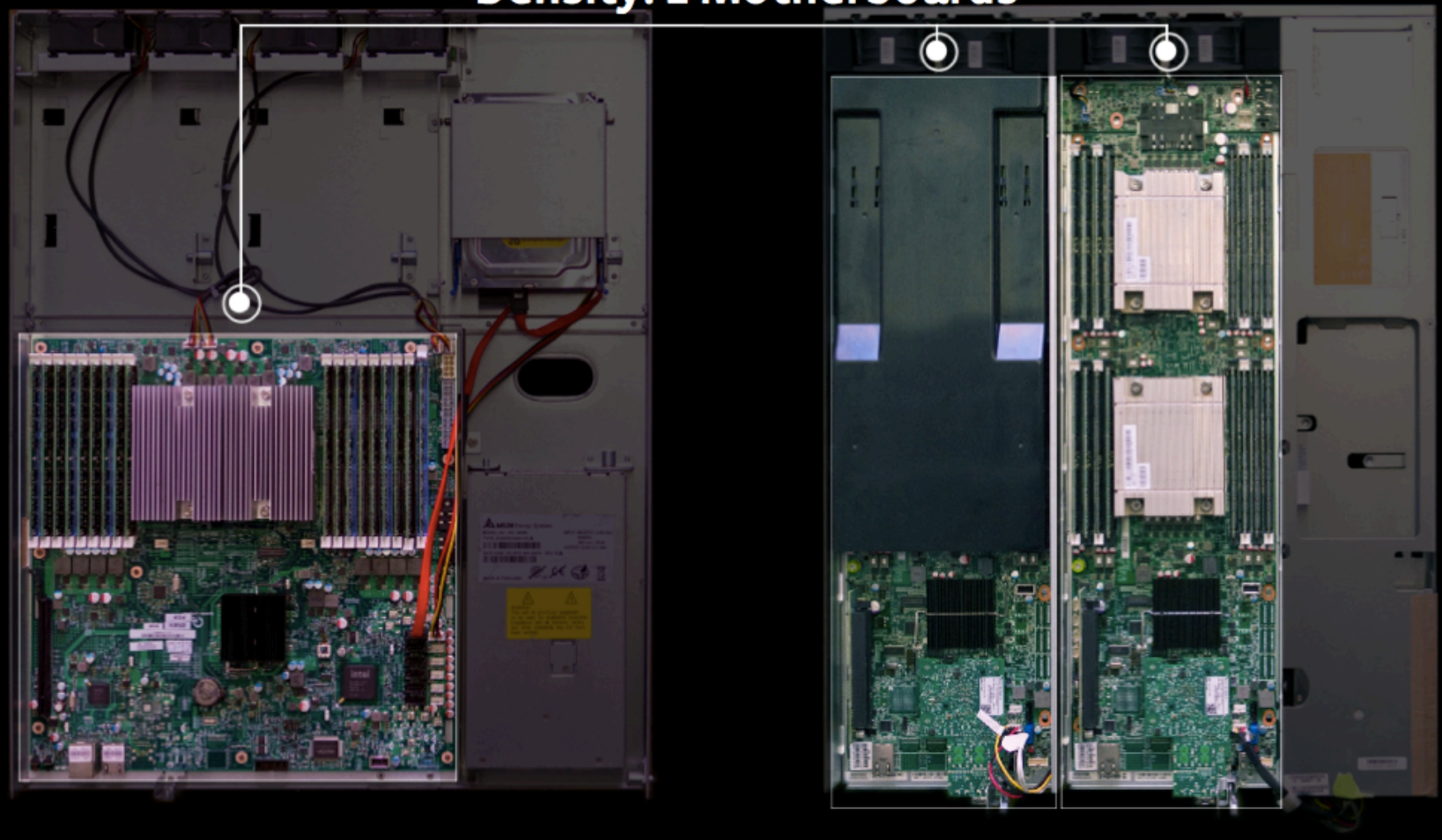



Web v1
Web v2
Drive: Improved Serviceability

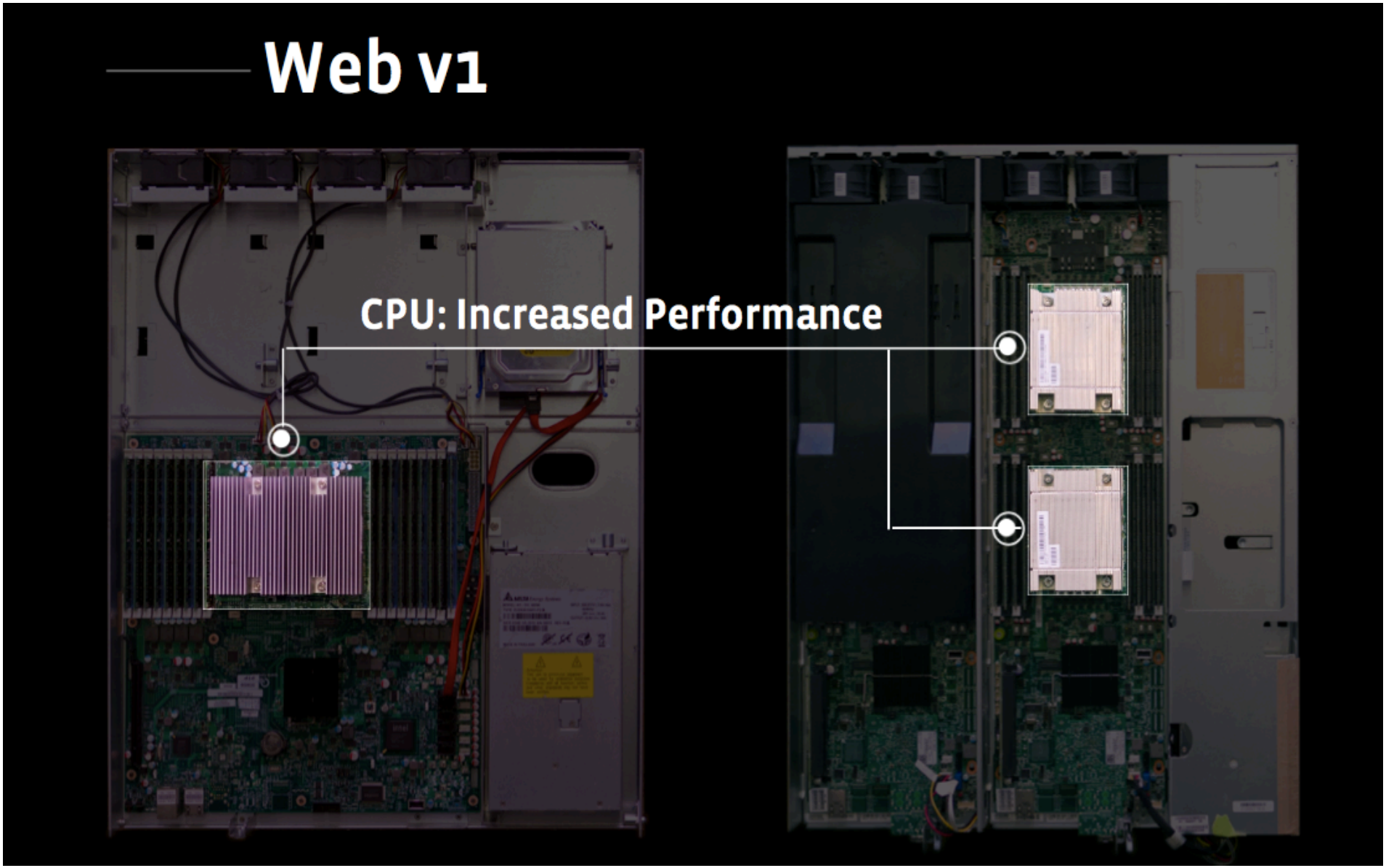
Web v1

Web v2

Density: 2 Motherboards



Web v1



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Storage Systems

	Total Size	Storage Technology	Bottlenecks
Social Graph	Single-digit petabytes	MySQL & Alternatives	Random read IOPS
Messages & Time Series Data	10s of petabytes	HBase and HDFS	Write IOPS & Storage capacity
Photos/Videos/BLOBs	100s of petabytes	Haystack	Storage capacity
Data Warehouse	100s of petabytes	Hive, HDFS, and Hadoop	Storage capacity
Cold Storage	Exabytes**	Custom	Storage Capacity

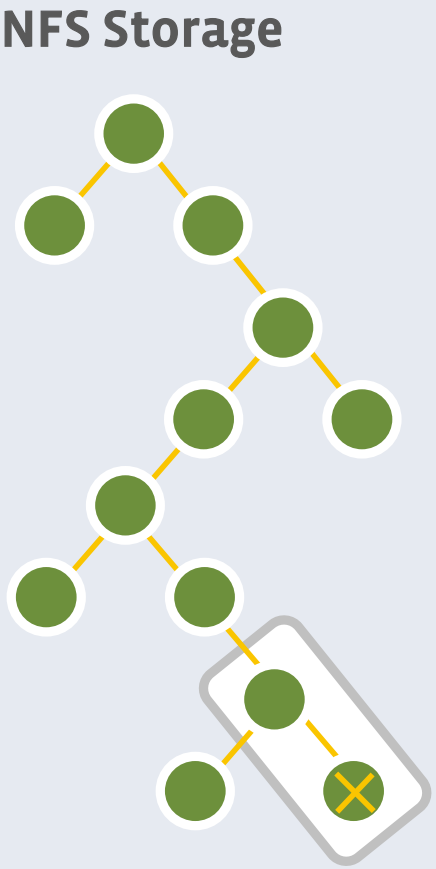
BLOB Storage

- Storage for Photos, Videos, Attachments, etc.

- Evolved over many generations
  - Constrained resource shifts and needs to be optimized for
    - Generation 1: Time to Market
    - Generation 2 & 3: Optimize the I/O request rate (Cost)
    - Generation 4: Optimize for Storage Efficiency (Cost)

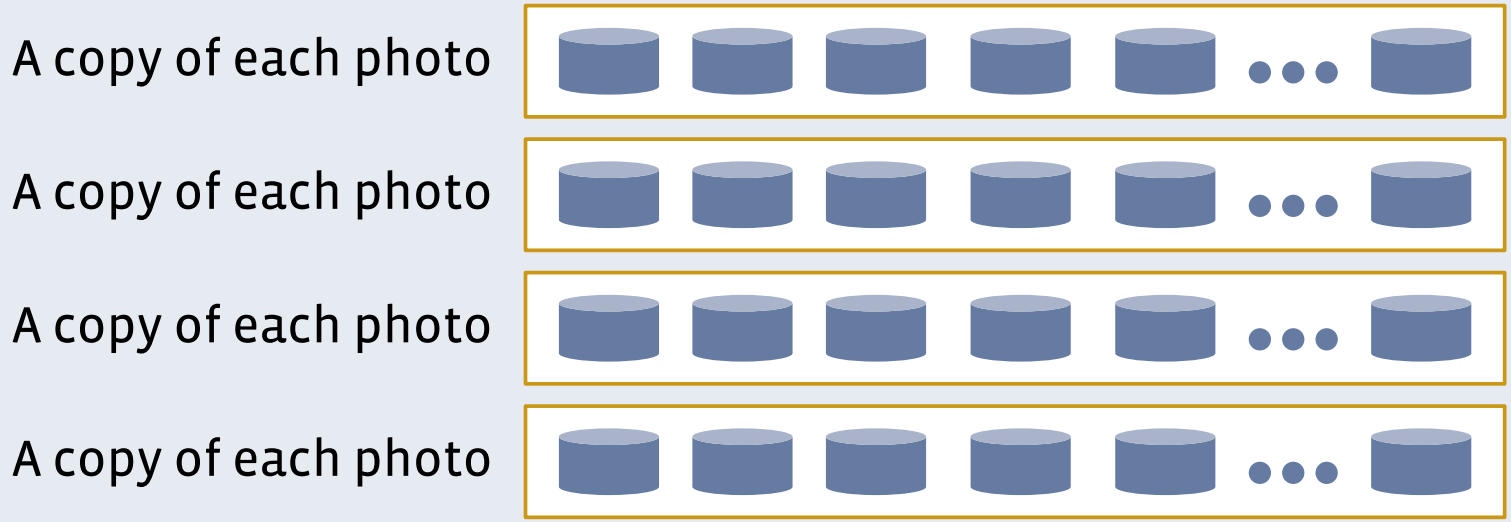
Generation 1: Commercial Filers

- New Photos Product
- First build it the easy way
  - Commercial Storage Tier + HTTP server
  - Each Photo is stored as a separate file
- Quickly up and running
  - Reliably Store and Serve Photos
- **But**: Inefficient
  - Limited by IO rate and not storage density
  - Average 10 IOs to serve each photo
  - Wasted IO to traverse the directory structure



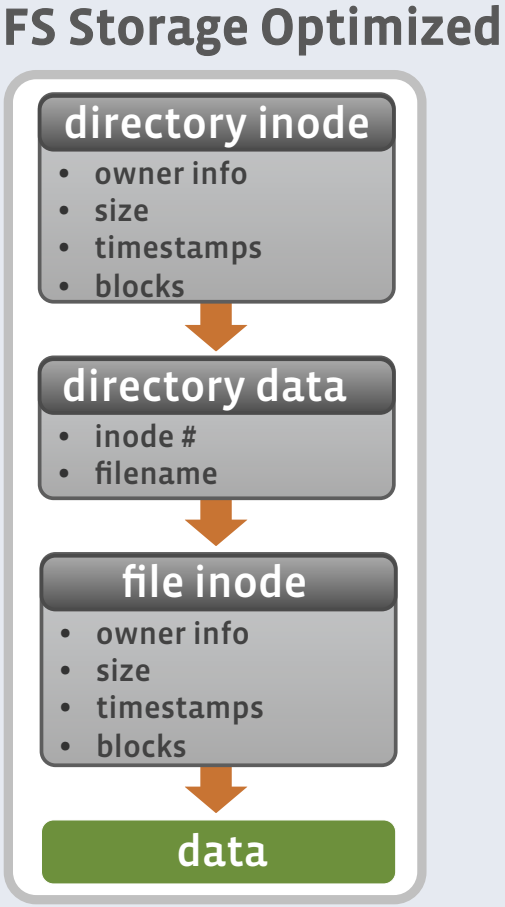
Effective but inefficient

- Disks are slow: 100 reads per disk per second
  - 1 photo read ➔ 10 disk reads
  - Each disk can serve 10 photos per second



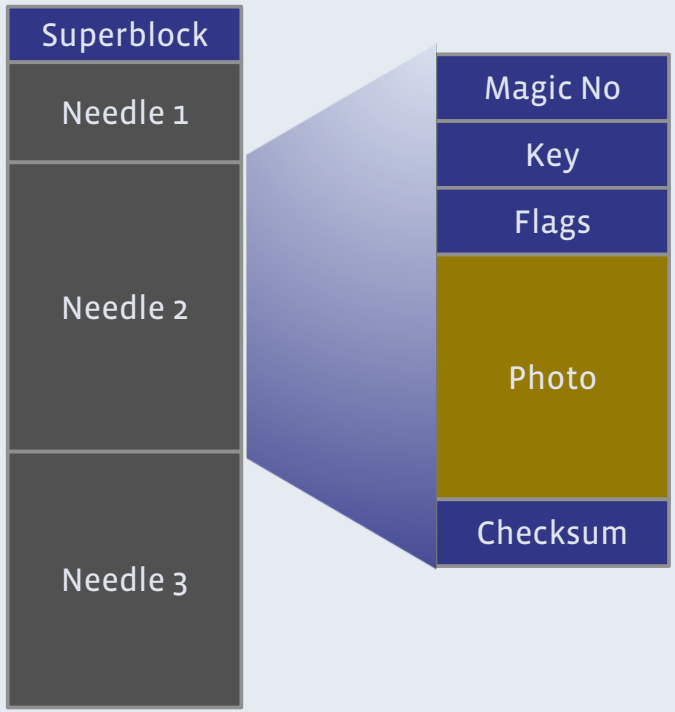
Generation 2: Gen 1 Optimized

- Optimization Example:
  - Cache NFS handles to reduce wasted IO operations
- Reduce the number of IO operations per photo by 3X
- **But**:
  - **Still expensive**: High end storage boxes
  - **Still inefficient**: Still IO bound and wasting IOs



Generation 3: Haystack [OSDI'10]

- Custom Solution
  - Commodity Storage Hardware
  - Optimized for 1 IO operation per request
    - **File system on top of a file system**
    - Compact Index in memory
    - Metadata and data laid out contiguously
- Efficient from IO perspective
- **But**:
  - Problem has changed now



Single Disk IO to read/write a photo

Photo lifecycle

Hot

Relevance

Time

Photo lifecycle

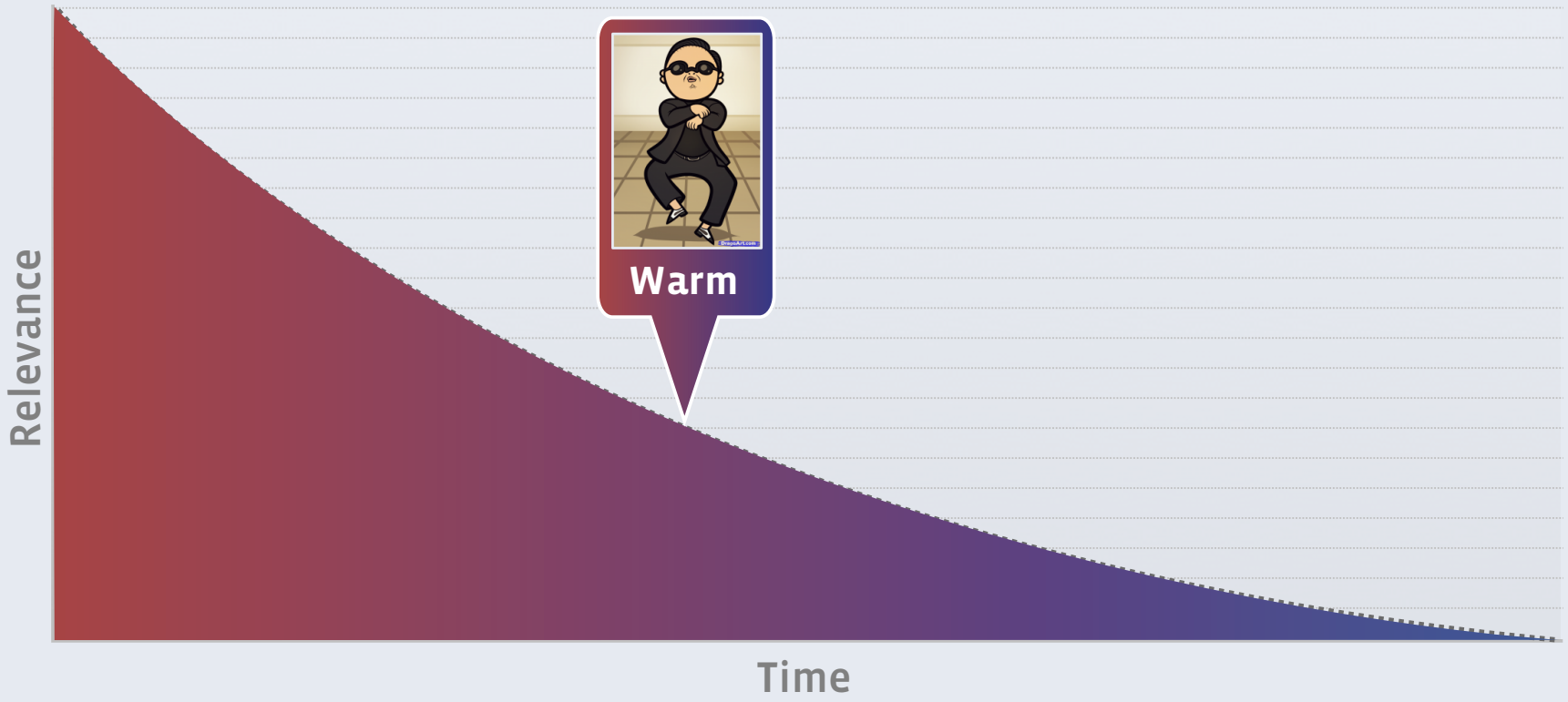
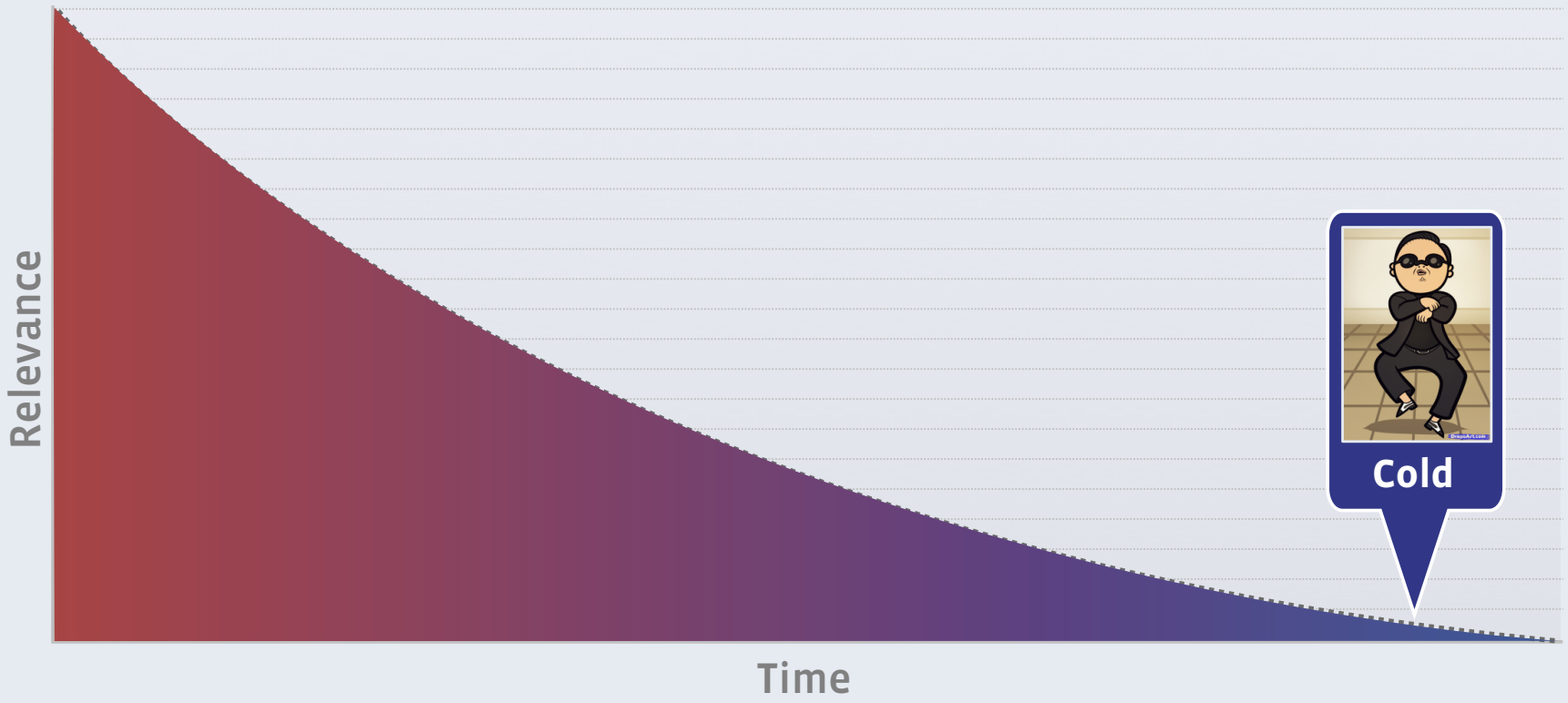
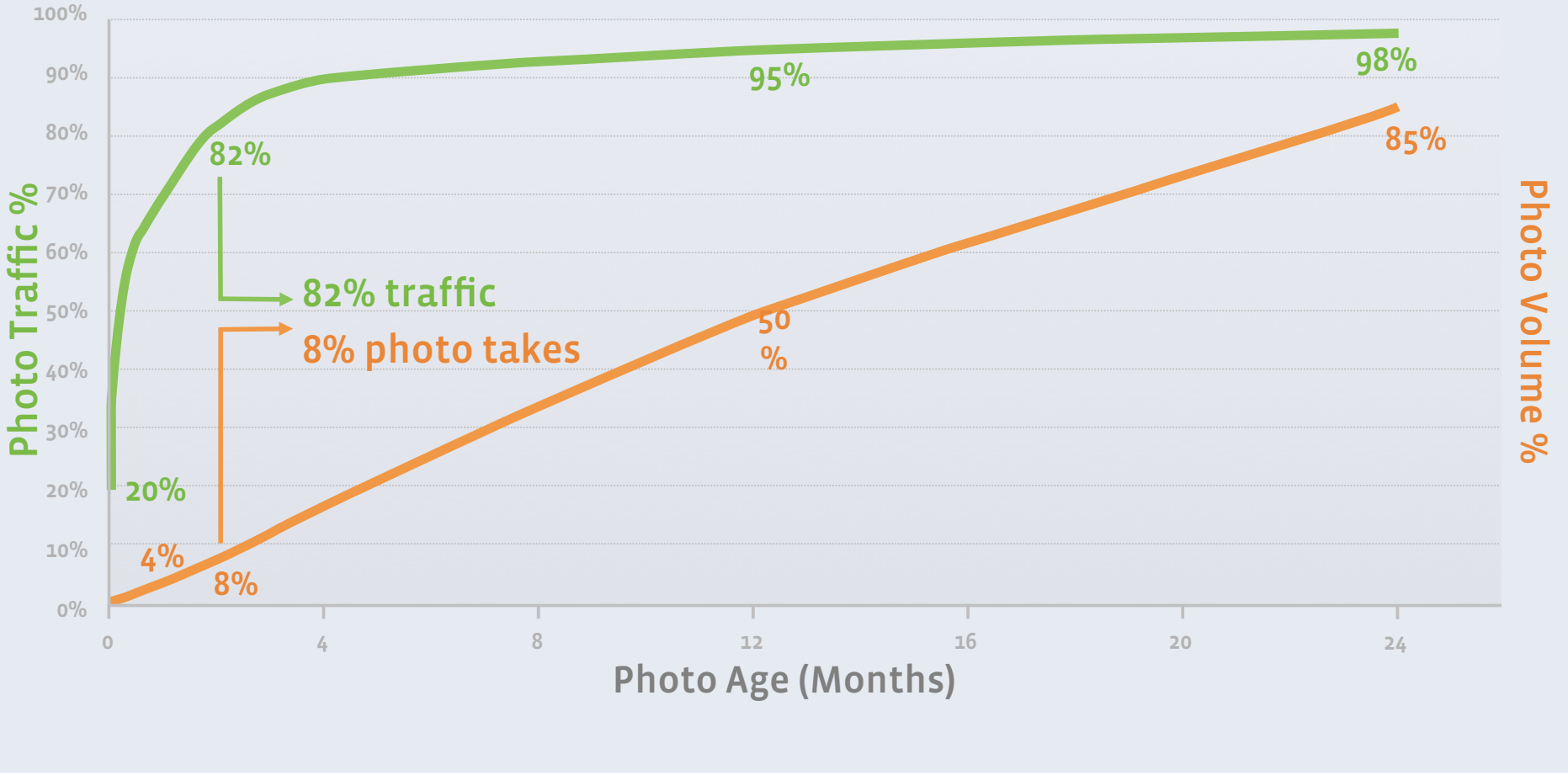


Photo lifecycle

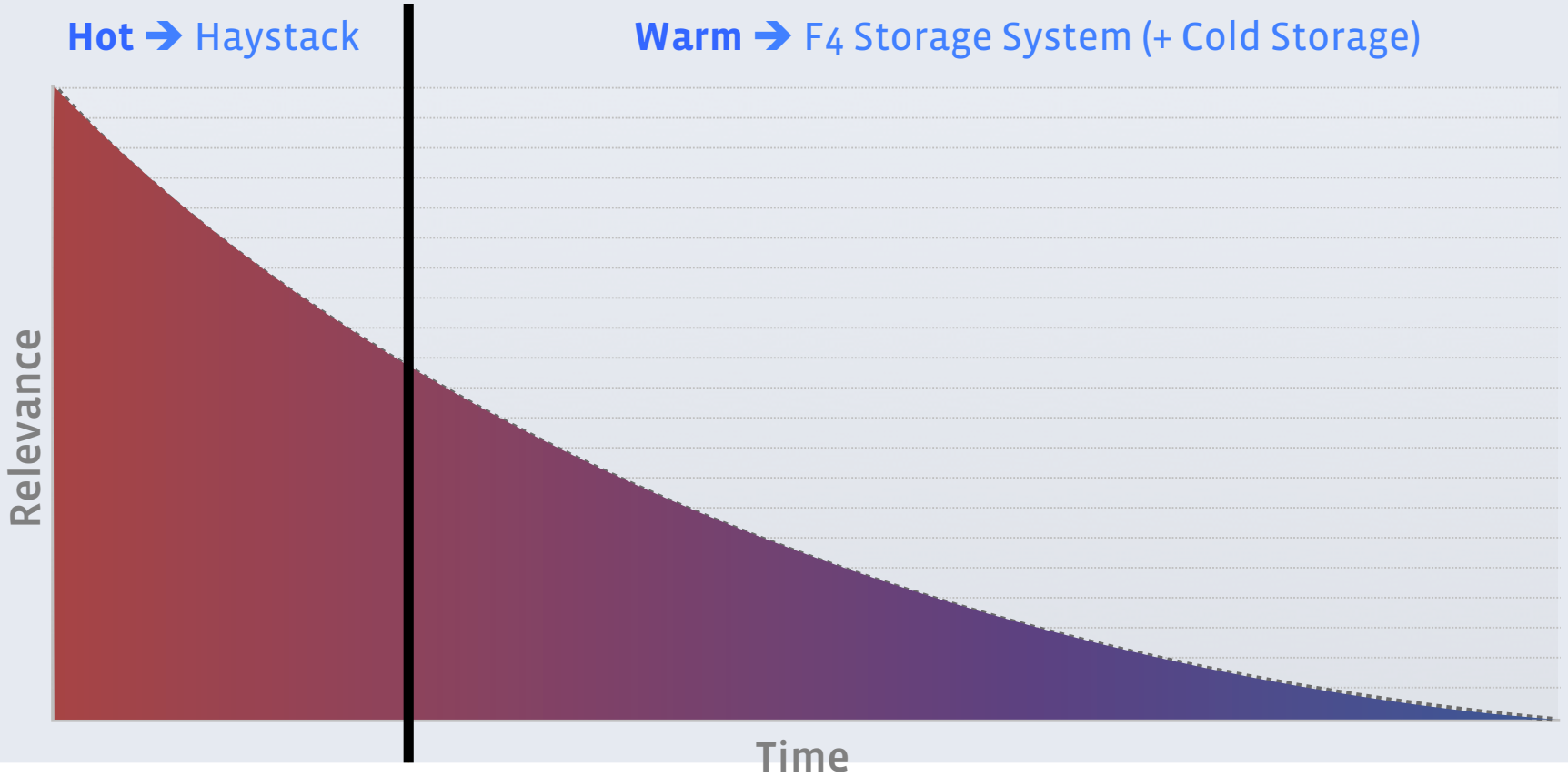


Access patterns



Generation 4: Tiered Storage

- Different storage solutions for hot, warm, cold photos



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