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Facebook: A *Canonical* Cloud Based Application

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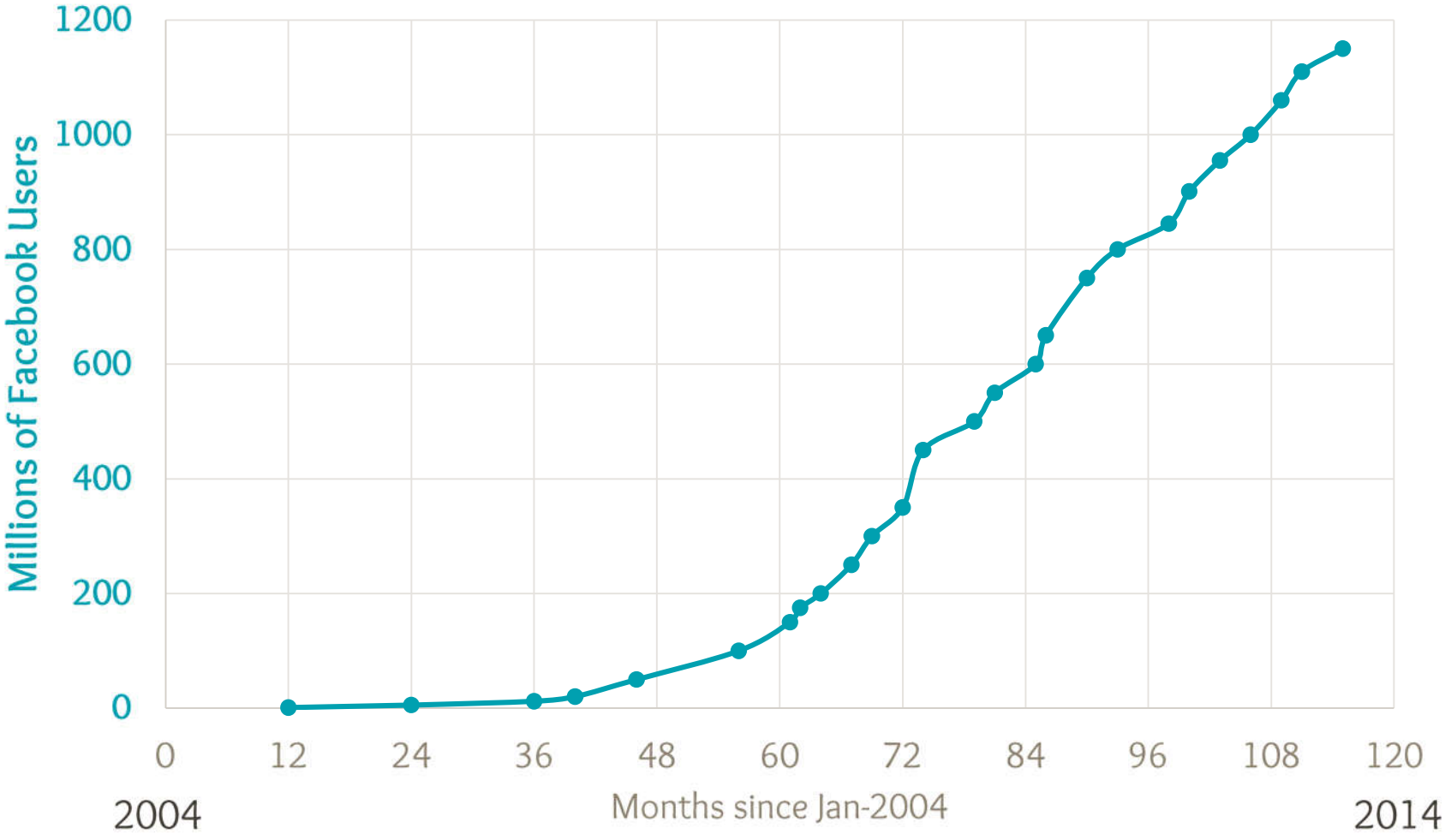
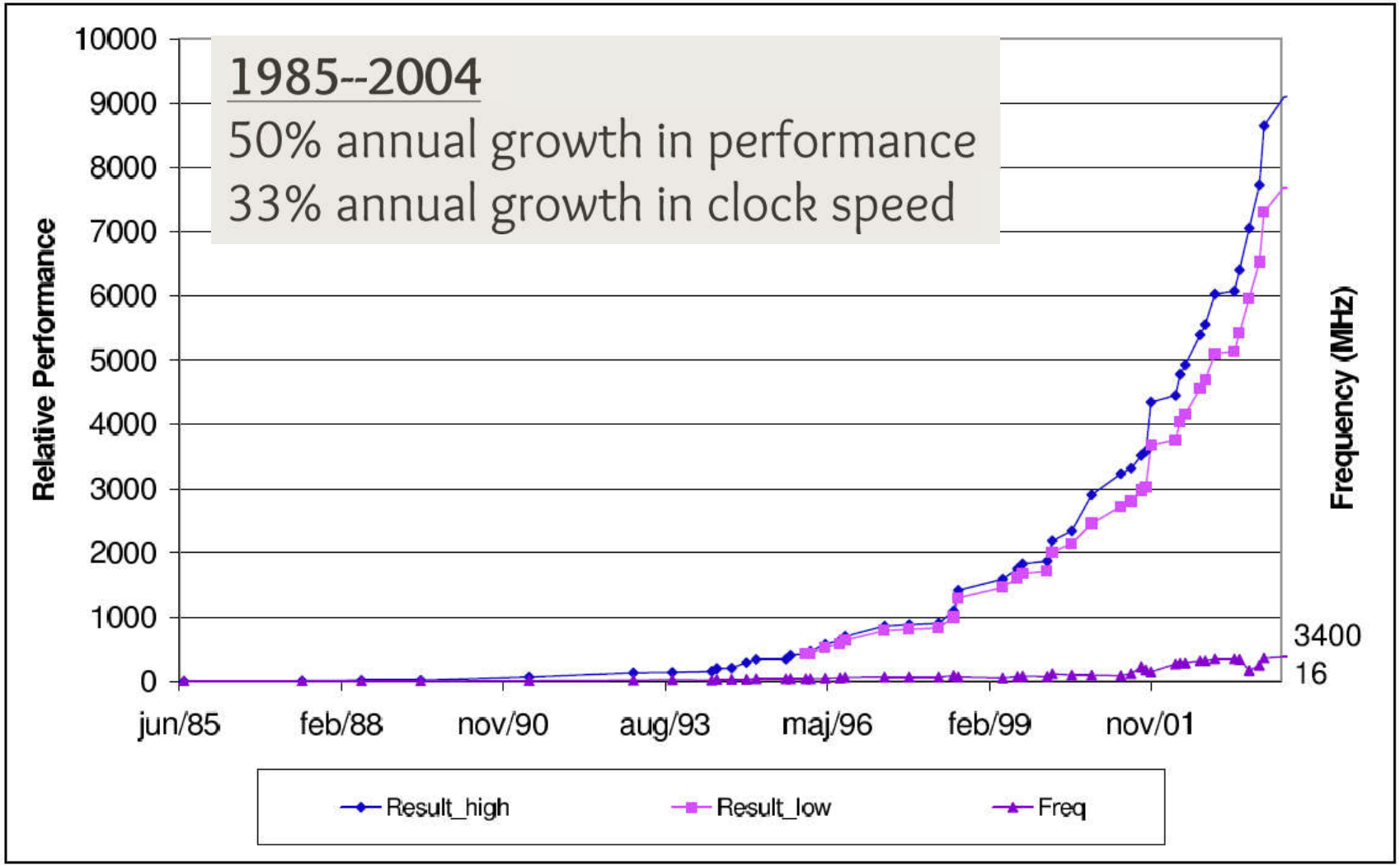
ILO1: Parallel and Distributed Systems Context

Growth of Facebook



http://www.benphoster.com/facebook-user-growth-chart-2004-2010/

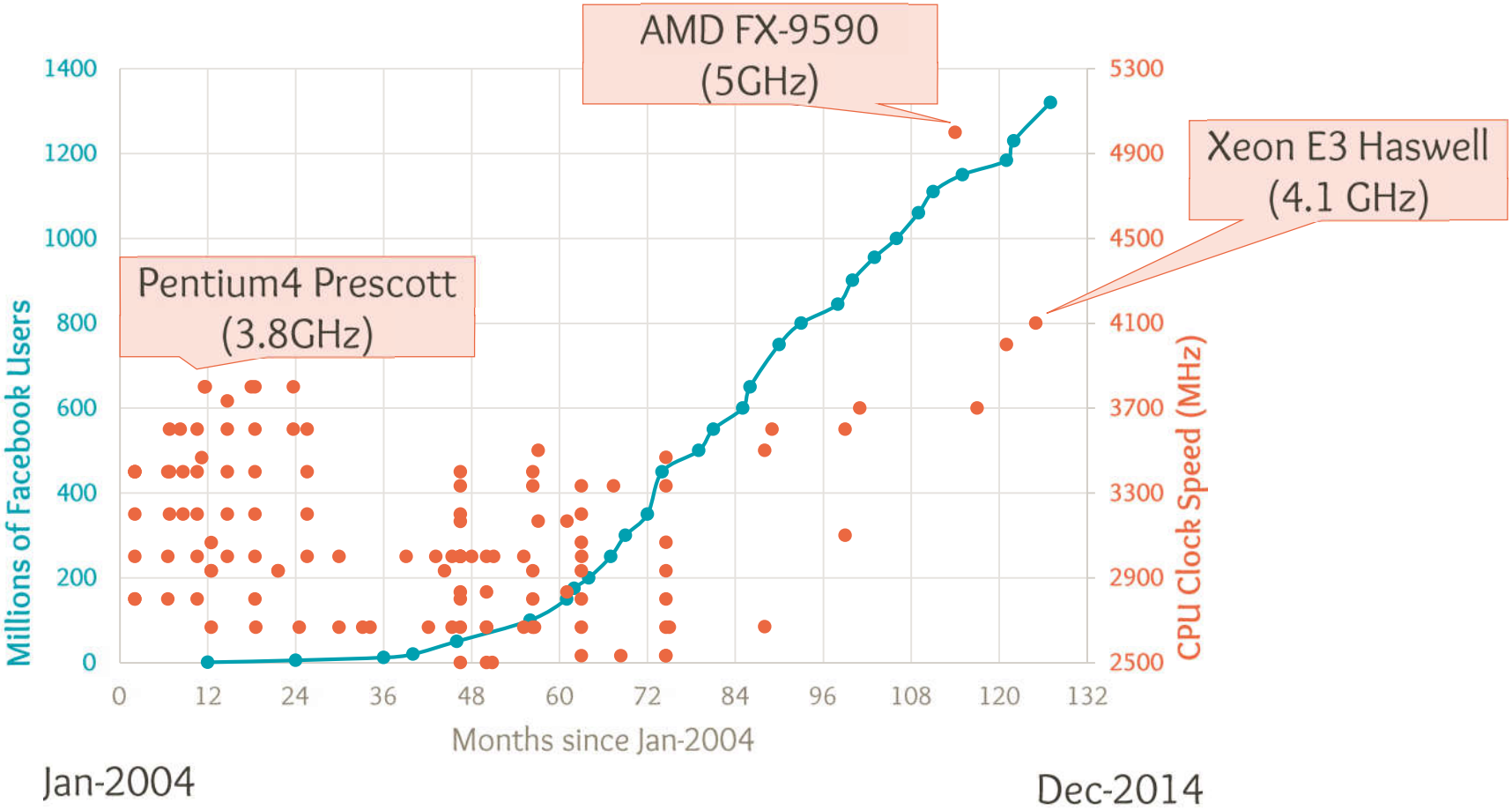
Single CPU Performance (Scale **UP**)



Computer performance 1985-2004, normalized to SPEC CINT89.

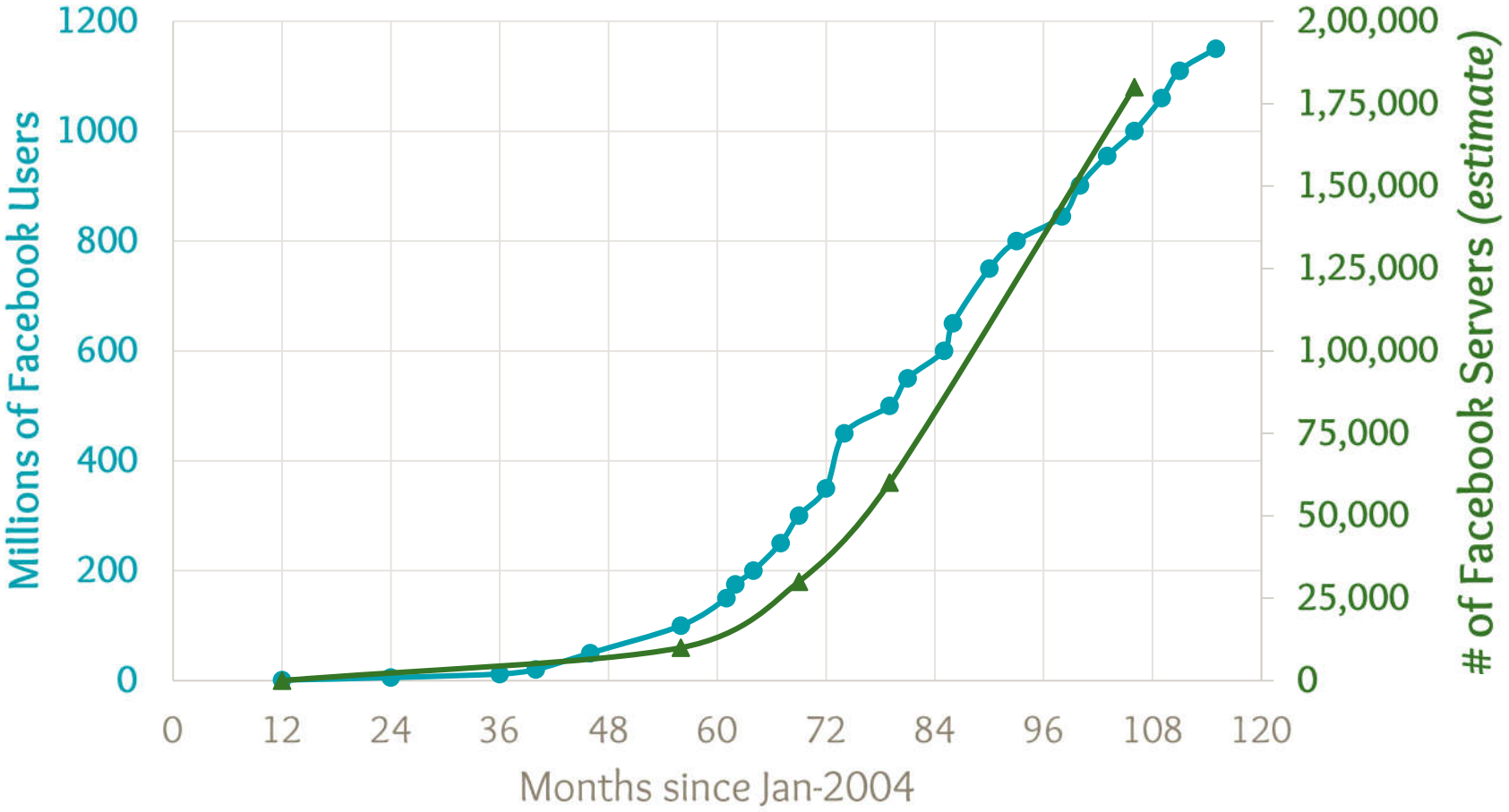
"An In-Depth Look at Computer Performance Growth", Ekman, et al, 2004

Facebook & Clock Speed Growth



http://www.r-bloggers.com/cpu-and-gpu-trends-over-time/

Facebook & Scale **OUT**



Scale **Up** vs Scale **Out**

- Understand parallel computing paradigms
  - Shared memory vs. Distributed memory
  - Parallel, Distributed, Cloud, …
  - Concurrency from micro to macro scale
  - Performance, scalability, efficiency
- Taxonomy, Pros & Cons, When to pick what, …
- ILO1: Parallel and Distributed Systems Context

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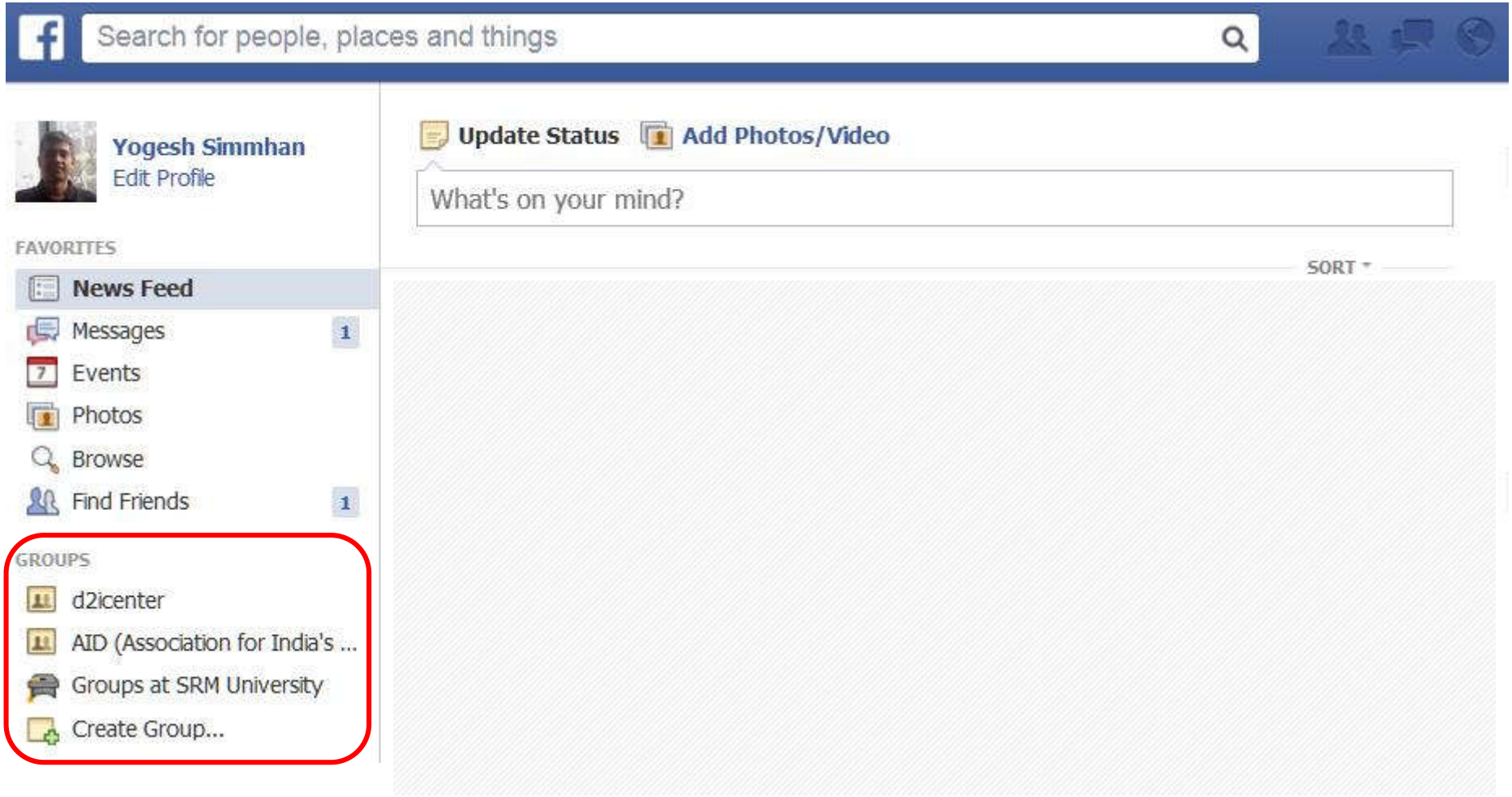
IL02: Cloud Virtualization, Abstractions and Enabling Technologies

My Facebook "Groups"



My Browser

Internet

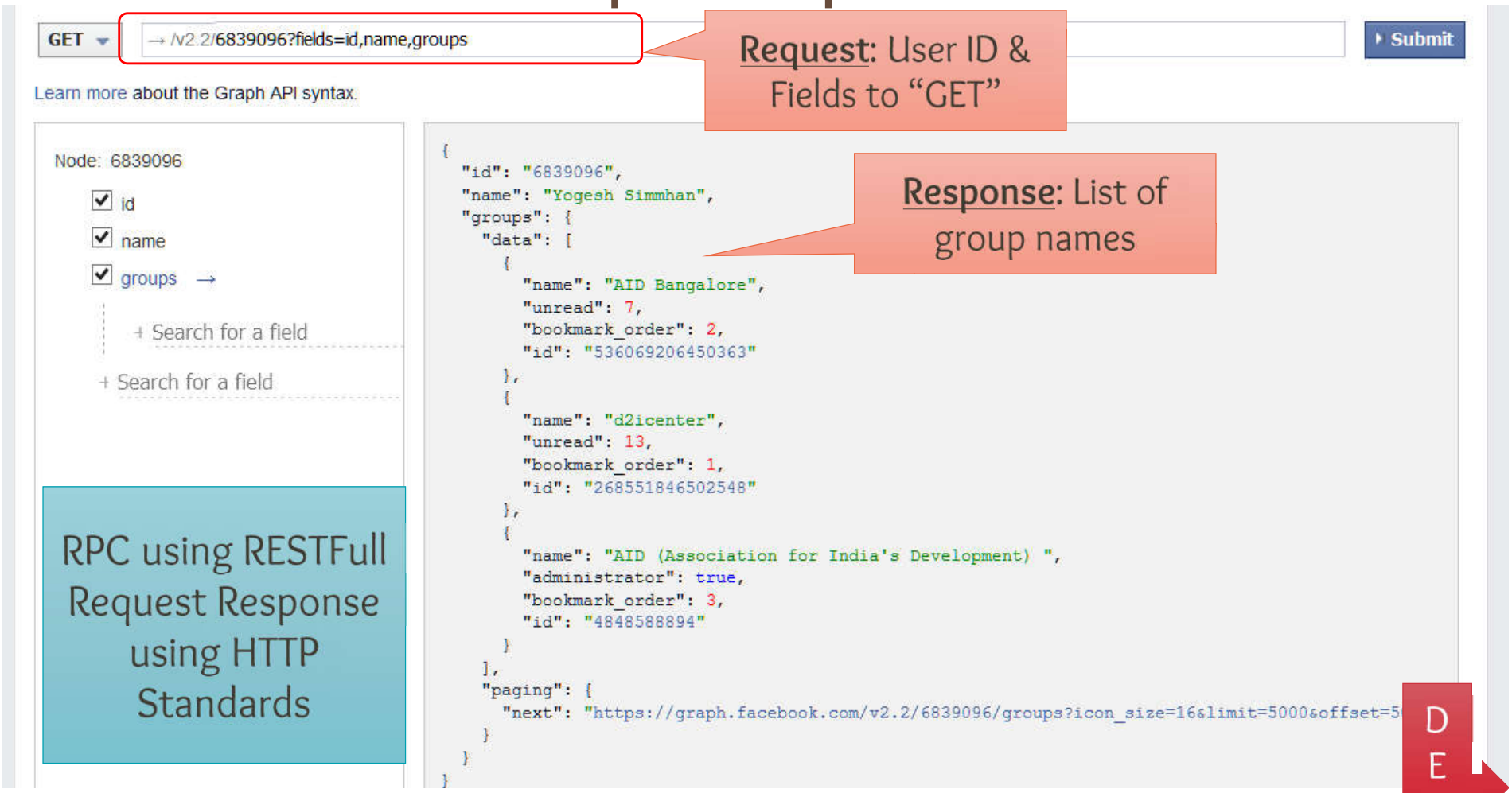
"Facebook" Server

Client-Server Interactions

- Request-Response model
- Often ask for a static content
  - https://www.facebook.com/images/loaders/indicator_blue_medium.gif
  - https://fbstatic-a.akamaihd.net/rsrc.php/v2/yK/r/Rf0y2zAXKrZ.gif
  - Served by facebook or other Content Distribution Networks
- Sometimes perform a "Remote Procedure Call"
  - Get the list of groups that I belong to
- Serialization, deserialization

developers.facebook.com/tools/explorer

Facebook Graph Explorer



DEMO

https://graph.facebook.com/v2.2/6839096?fields=id%2Cname%2Cgroups&format=json&method=get

Service Oriented Architecture (SOA)

- Allows standard way for clients & services to
  - Exchange data Structures over the network
    - » Serialization & Deserialization
  - Invoke remote methods over the network
  - Defining QoS, discovering services, etc.
- SOA is an enabling *technology* for Clouds
  - E.g. SOAP, REST, Thrift*, Protocol Buffers, etc.
  - RPC *concept* has existed since 1980's

***Thrift: Scalable Cross-Language Services Implementation,** Mark Slee, Aditya Agarwal and Marc Kwiatkowski, 2007

SOA & Virtualization

- All Cloud operations can be performed as web service calls by application
  - Storage services, VM Management services,...
- Virtualization is the other key enabler
- ILO2: Cloud Virtualization, Abstractions and Enabling Technologies

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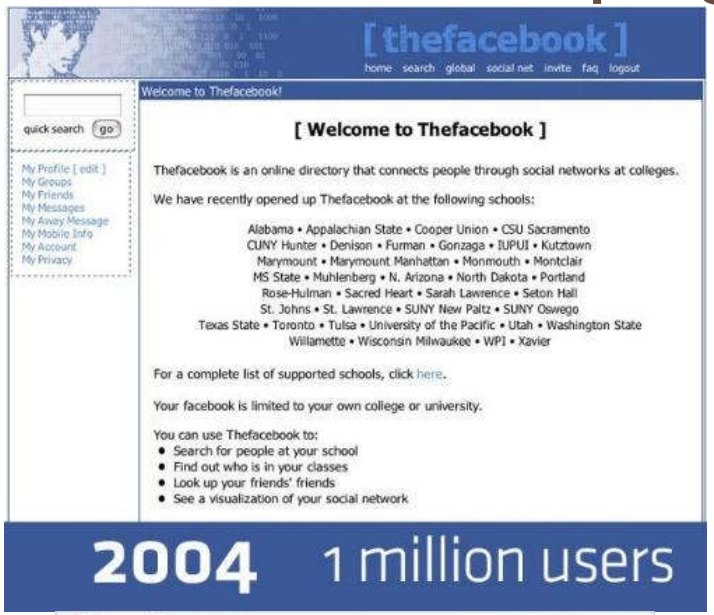
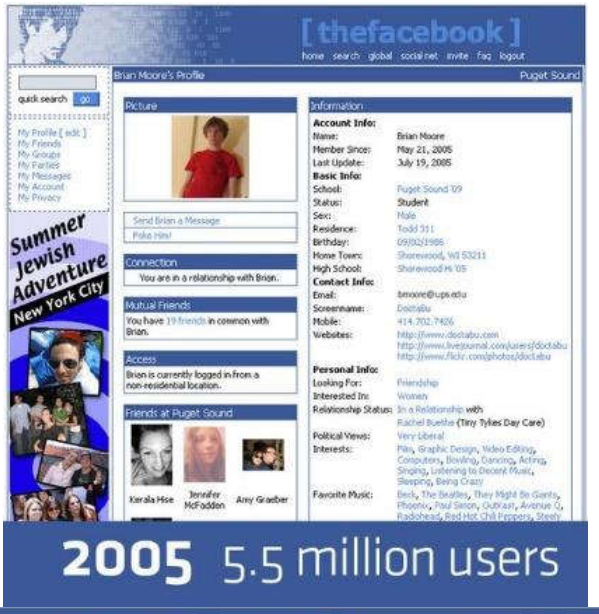
IL03: Algorithms and Programming Patterns for Cloud Applications

Facebook Webpage over the Years

http://mashable.com/2011/02/04/facebook-7th-birthday/





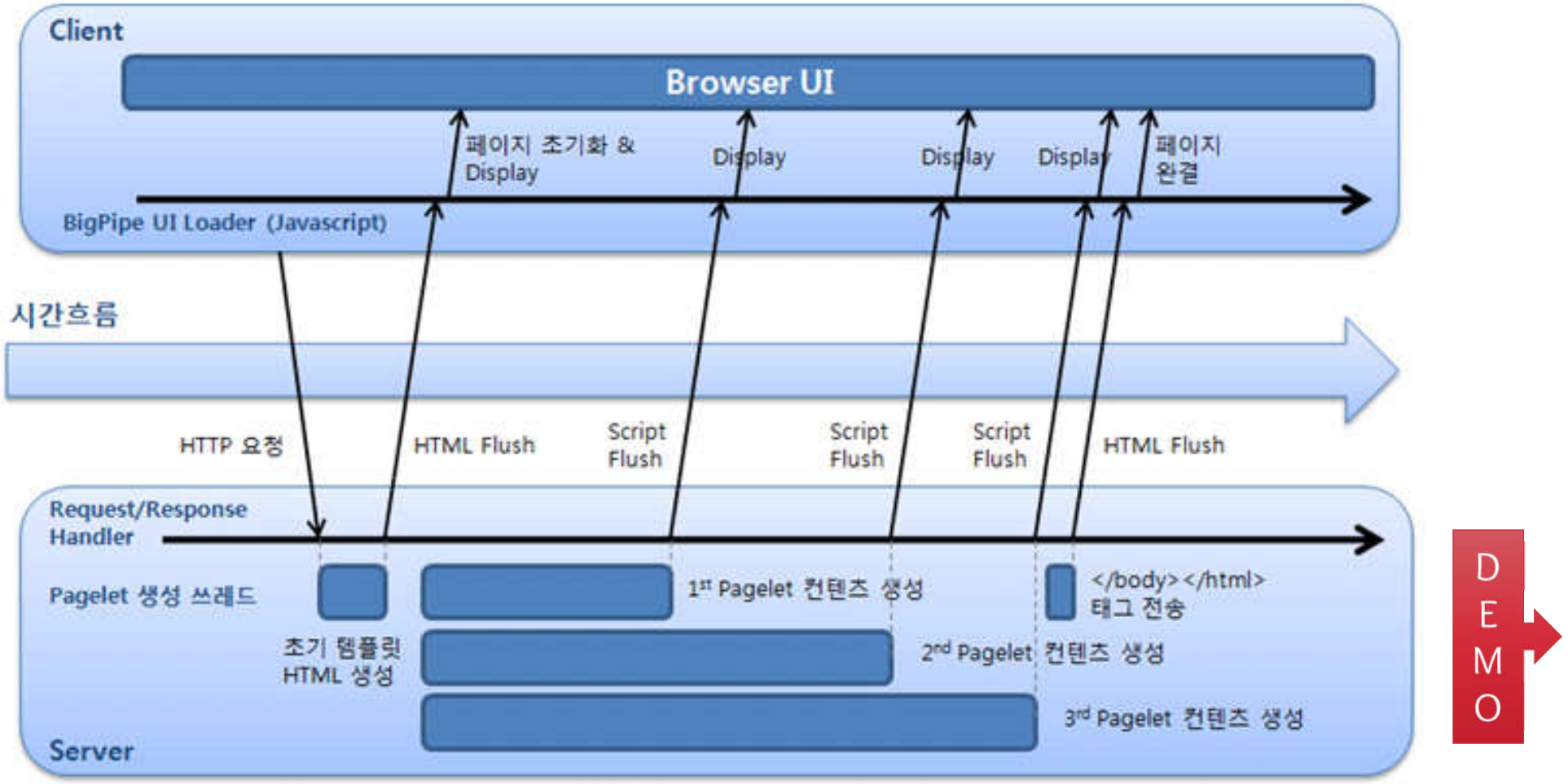
Facebook Webpage over the Years

http://mashable.com/2011/02/04/facebook-7th-birthday/

Facebook's BigPipe

https://www.facebook.com/note.php?note_id=389414033919

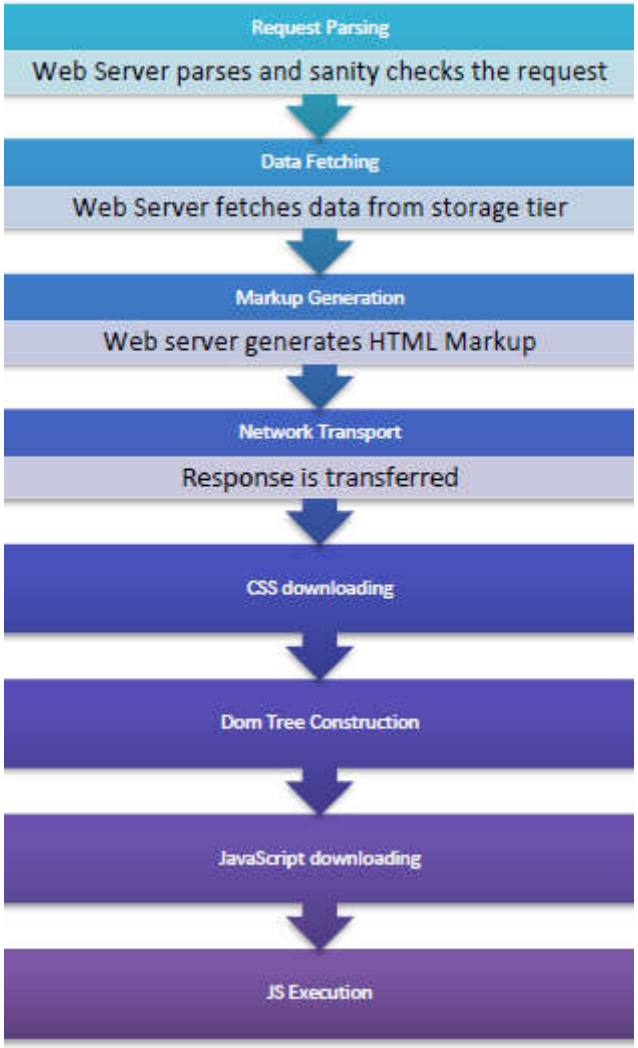
Pipelined vs Single Shot Page Loading



http://www.cubrid.org/blog/dev-platform/faster-web-page-loading-with-facebook-bigpipe/

Data Parallel Execution

- Each *pagelet* is independent unit of rendering
- Same set of tasks executed for each pagelet (data), *in parallel*
  - CSS D/L, JS D/L, Render
- This is also a task "graph"
  - Sequence of tasks that execute one after the other



http://www.slideshare.net/AditiTechnologies/facebook-architecture-breaking-it-open

Data & Task Parallel Models

- Data parallel model is common in Clouds
  - E.g. Map-Reduce, Giraph
  - Helps exploit independent units of data on multiple machines/processors/threads
- Task parallel model help in composition
  - Allows tasks to operate concurrently on same/different data

- ILO3: Algorithms and Programming Patterns for Cloud Applications

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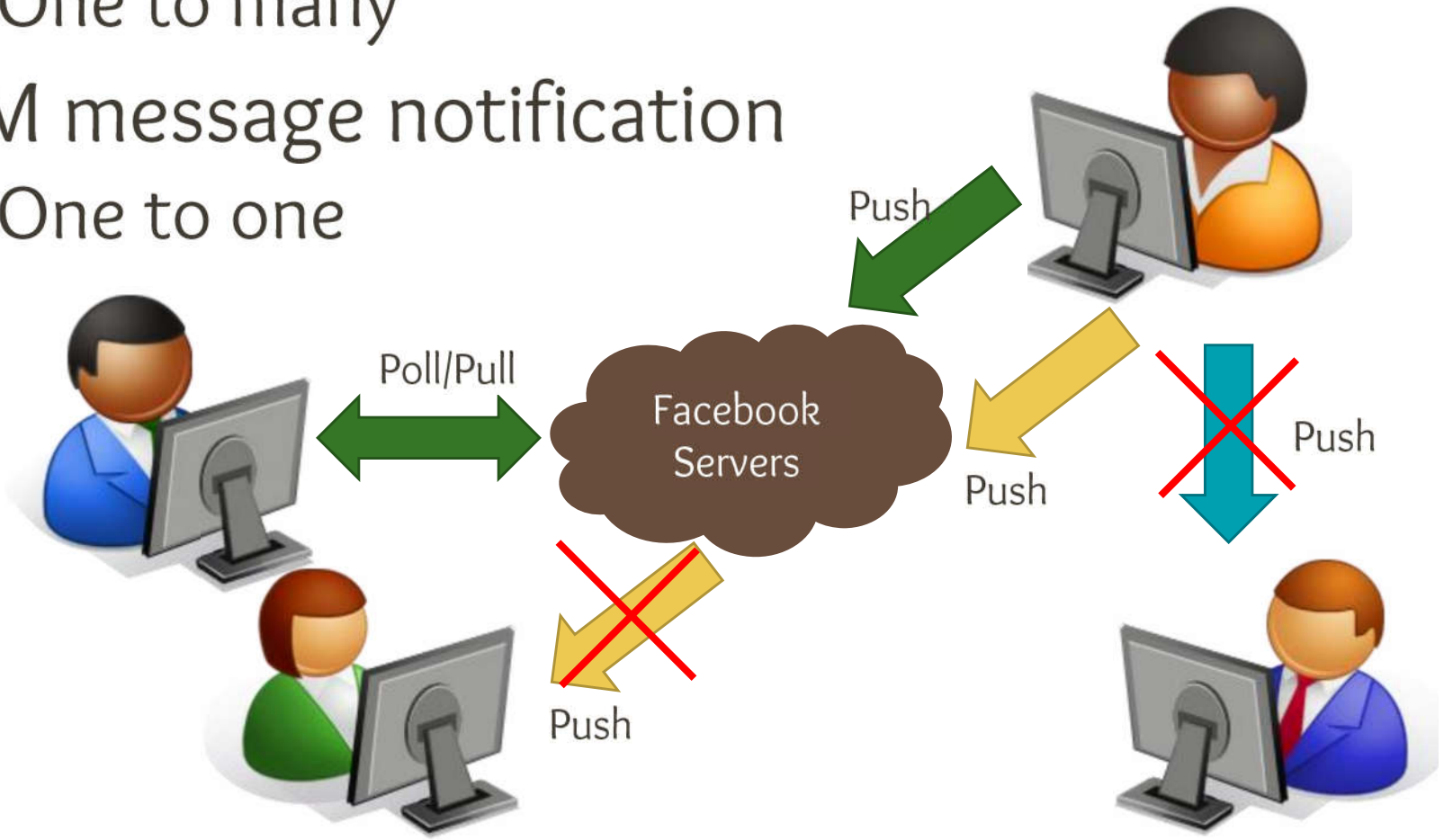
ILO 4: Application Execution Models on Clouds

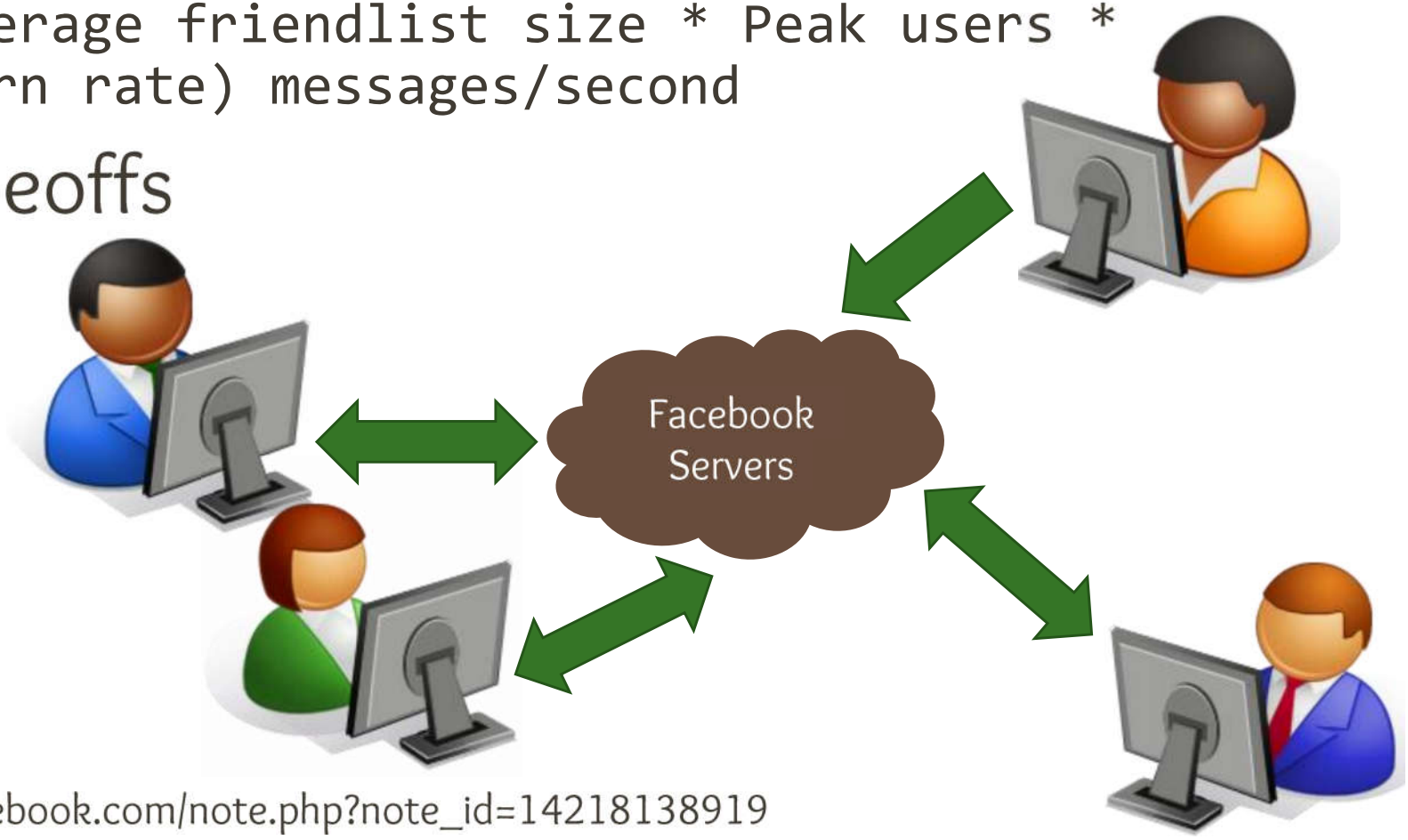
Facebook (Browser) Chat

- Online/offline status
  - One to many
- IM message notification
  - One to one



Synchronous vs Asynchronous

- Immediately or eventually delivered?
  - Cost of sync goes up with # of users
  - `(Average friendlist size * Peak users * Churn rate) messages/second`
- Tradeoffs



https://www.facebook.com/note.php?note_id=14218138919

Programming Cloud Apps

- Coordinate execution across VMs, clients
- Synchronization of activities
- Storage-based vs. In-memory operations
- Trade-off between guarantees

- ILO 4: Application Execution Models on Clouds

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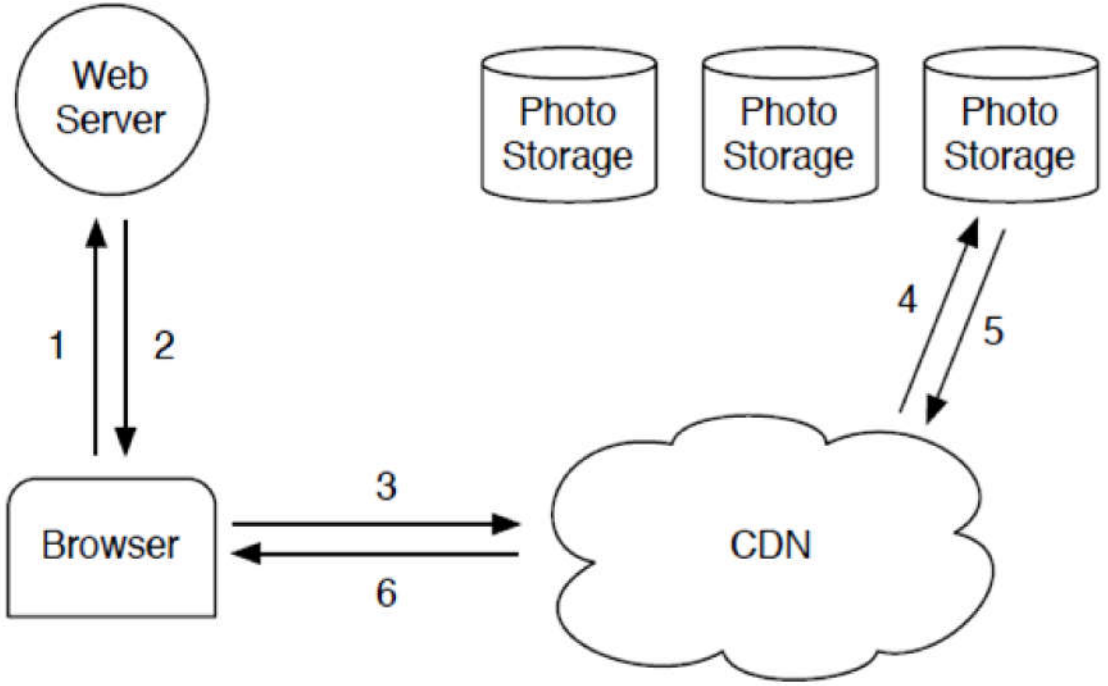
IL05: Performance, scalability & consistency on Clouds

Data Locality for Facebook Photos

- Content Distribution Networks (CDN)
  - Host "Hot" data, Spatially close to the client
  - E.g. Akamai
- Low latency
- Freshness?
- Consistency?



Finding a needle in Haystack: Facebook's photo storage
Doug Beaver, Sanjeev Kumar, Harry C. Li, Jason Sobel, Peter Vajgel

Performance, Availability, Consistency, Scalability, …

- CDNs are costly for long tail
  - And poor cache hits
- Haystack
  - Incremental URLs
  - Better caching
  - Low latency response

- ILO5: Performance, scalability & consistency on Clouds