Smart Health – CSE 40816

University of Notre Dame

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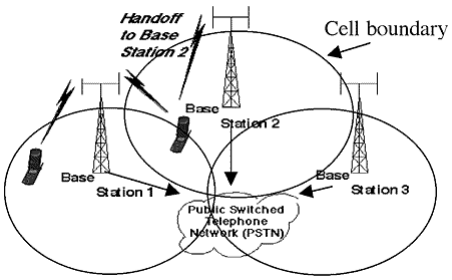
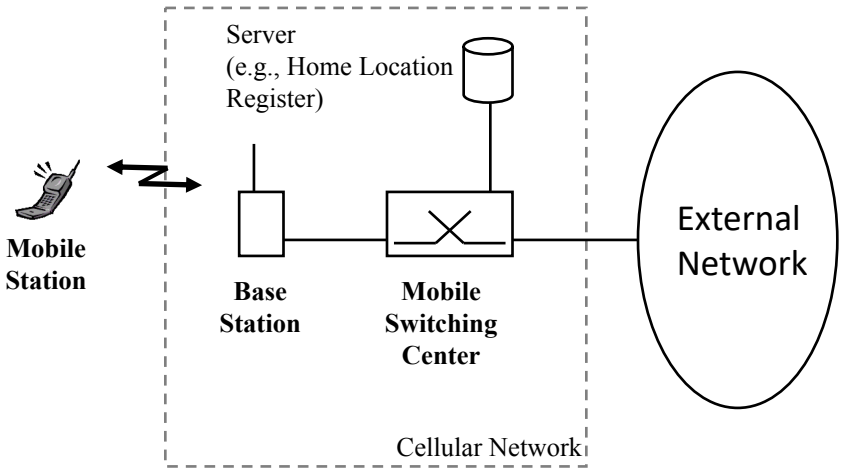
UNIVERSITY OF NOTRE DAME

Cellular Networks

- **Base stations** transmit to and receive from mobile devices at the assigned spectrum
  - Multiple base stations use the same spectrum (**spectral reuse**)
- The service area of each base station is called a **cell**
- Each mobile terminal is typically served by the 'closest' base stations
  - **Handoff** when terminals move



Architecture of Cellular Networks



Cellular Network Generations

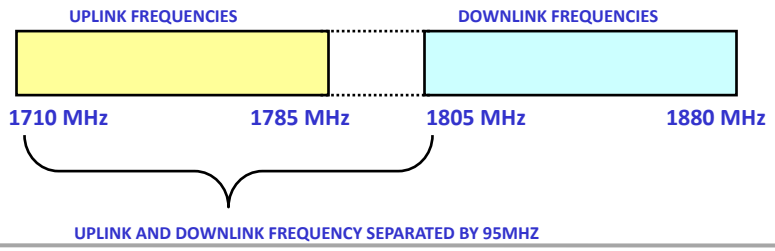
- It is useful to think of a cellular network in terms of ***generations***:
  - 0G: Briefcase-size mobile radio telephones
  - 1G: *Analog* cellular telephony
  - 2G: *Digital* cellular telephony
  - 3G: *High-speed* digital cellular telephony (including *video telephony*)
  - 4G: IP-based "anytime, anywhere" voice, data, and multimedia telephony at *faster* data rates than 3G

GSM (2G)

- Abbreviation for Global System for Mobile Communications
- Concurrent development in USA and Europe in the 1980s
- The European system was called GSM and deployed in the early 1990s
- Voice, 3.1 kHz
- Short Message Service (SMS)
  - 1985 GSM standard that allows messages of at most 160 chars. to be sent between handsets and other stations
  - Multi-billion $ industry

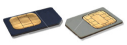
GSM Frequencies

- Originally designed on 900MHz range, now also available on 800MHz, 1800MHz and 1900 MHz ranges.
- **Separate uplink and downlink frequencies**
  - One example channel on the 1800 MHz frequency band, where RF carriers are spaced every 200 kHz



Mobile Station (MS)

- MS is the user's handset and has two parts
- Mobile device
  - Equipment **IMEI** (Intl. Mobile Equipment Identity)
- Subscriber Identity Module (SIM)
  - Subscriber **IMSI** (Intl. Mobile Subscriber Identity)
    - 64 bit number; includes:
      - MCC (Mobile Country Code): 3 decimal places, intl. standardized
      - MNC (Mobile Network Code): 2 decimal places, network within country
      - MSIN (Mobile Subscriber Identification Number): max. 10 decimal places



5G Challenges & Scenarios

Avalanche of
Traffic Volume

Further expansion of mobile broadband

Additional traffic due to communicating machines

"1000x in ten years"

Massive growth in
Connected Devices
"Communicating machines"

"50 billion devices in 2020"

Large diversity of
Use cases & Requirements

Device-to-Device Communications

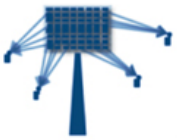
Car-to-Car Comm.

New requirements and characteristics due to communicating machines

5G Technologies

Massive MIMO

Dramatically increase number of antenna elements on base station

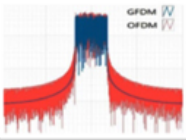


Ultra-Dense Networks

Substantially reduce cell sizes to handle more users

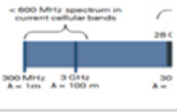
5G Waveforms

Improve bandwidth utilization through signal structure improvements such as NOMA, GFDM, FBMC, and UFMC



mmWave

Utilize potential of extremely wide bandwidths at frequency ranges once thought impractical for commercial wireless



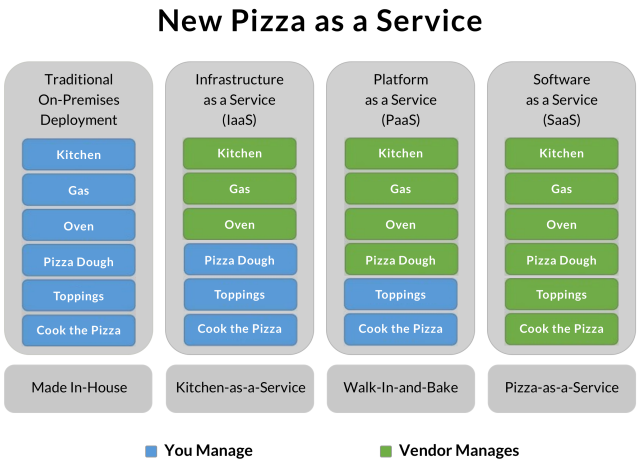
Summary

1G	2G	3G	4G	5G
1981	1992	2001	2010	2020(?)
2 Kbps	64 Kbps	2 Mbps	100 Mbps	10 Gbps
Basic voice service using analog protocols	Designed primarily for voice using the digital standards (GSM/CDMA)	First mobile broadband utilizing IP protocols (WCDMA / CDMA2000)	True mobile broadband on a unified standard (LTE)	'Tactile Internet' with service-aware devices and fiber-like speeds
				?

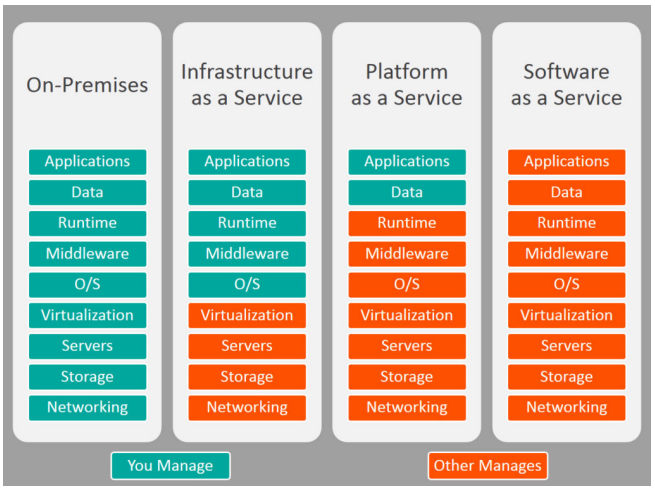
Cloud Computing

- "Cloud computing is a model for enabling available, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." [NIST.GOV]
- "Pay-per-use" where relevant (differs from "hosted" environments, where model is "pay for maximum capacity")
- Treats IT more as a **utility** than as a capital expense that must be managed and upgraded

Cloud Computing Delivery Models



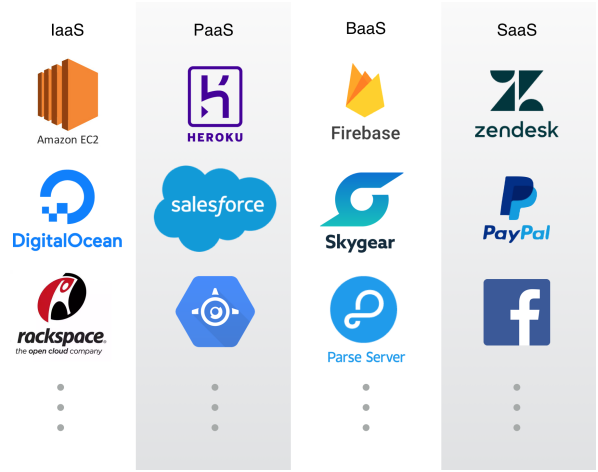
Cloud Computing Delivery Models



Cloud Computing Delivery Models

- **Software-as-a-Service (SaaS):** an application environment is provided
- **Platform-as-a-Service (PaaS):** an application development platform is provided
- **Infrastructure-as-a-Service (IaaS):** infrastructure capabilities (such as storage or a bare operating system) are provided

Cloud Computing Delivery Models



Mobile Apps & Cloud Computing

- **Mobile Cloud Computing (MCC)**
  - **Infrastructure where both the data storage and data processing happen outside of the mobile device**

- Mobile cloud applications move the computing power and data storage away from the mobile devices and into powerful and centralized computing platforms located in clouds, which are then accessed over the wireless connection based on a **thin native client**

Cloud Computing Delivery Models

- **Software-as-a-Service (SaaS):** an application environment is provided
- **Platform-as-a-Service (PaaS):** an application development platform is provided
- **Infrastructure-as-a-Service (IaaS):** infrastructure capabilities (such as storage or a bare operating system) are provided
- **Backend-as-a-Service (BaaS):** a cloud service model in which developers outsource all the behind-the-scenes aspects of a web or mobile application so that they only have to write and maintain the frontend (also MBaaS)

Mobile Cloud Computing – Why?

- Limited mobile resources
  - Battery, storage, processing, network, …
  - Consider tradeoffs!

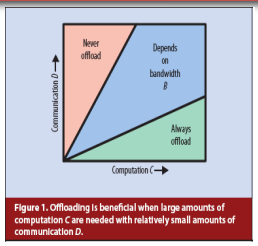


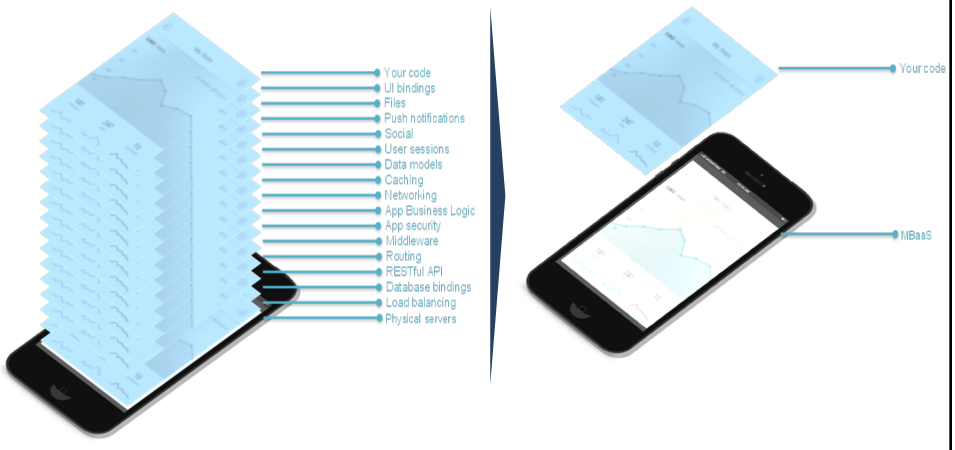
Figure 1. Offloading is beneficial when large amounts of computation C are needed with relatively small amounts of communication D.

- Permanent storage
  - Backup (reliability), long-term storage, anywhere access (availability)
- Data sharing
  - Social media, sensor data, collaboration, producer-consumer, …

Mobile Cloud Computing

- More resources
- Reliability and availability
- Sharing of data & information
- Control access of data
- MCC allows for dynamic provisioning
  - Resources always available; no need for reservation
  - Mobile applications can be scaled to meet user demands
  - Services can be added and expanded easily
  - Multiple services can be integrated through cloud
- New/additional services possible (or easier)
  - Mobile payment
  - Push notifications
  - Advertising
  - Analysis tools
  - Social network integration
  - User management tools

MBaaS – Focus on Frontend!

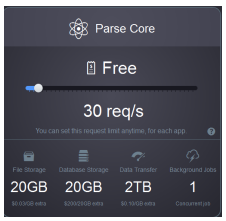


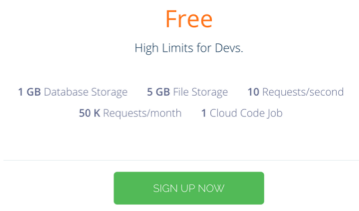
MBaaS Providers

kinvey
FEEDHENRY
amazon web services
anypresence
appcelerator
Google Cloud Platform Live
built.io
apigee
APIOMAT Backend as a Service
back{4}app
heroku
Sencha
TruJunction
Firebase

Example: Back4app (parse.com)

- Founded in 2011
- Acquired by Facebook in 2013
- More than 500,000 apps in 2014
- Shut down January 2017
- Made code open-source
- Many replacements, including self-hosted
- Back4app.com

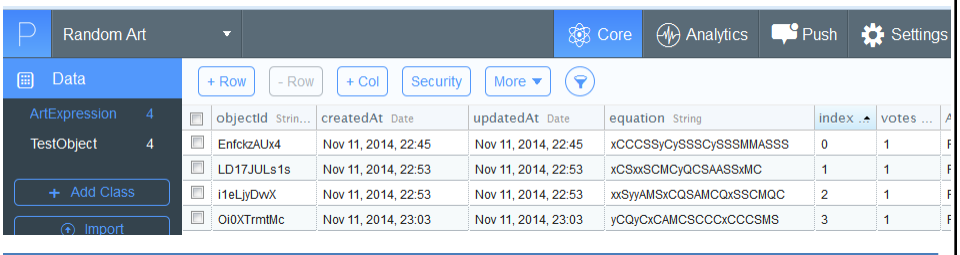




Back4app

- www.back4app.com
- iOS: http://docs.back4app.com/docs/ios/
- Android: http://docs.back4app.com/docs/android/
- Cloud Code: http://docs.back4app.com/docs/integrations/

Parse/Back4app Dashboard



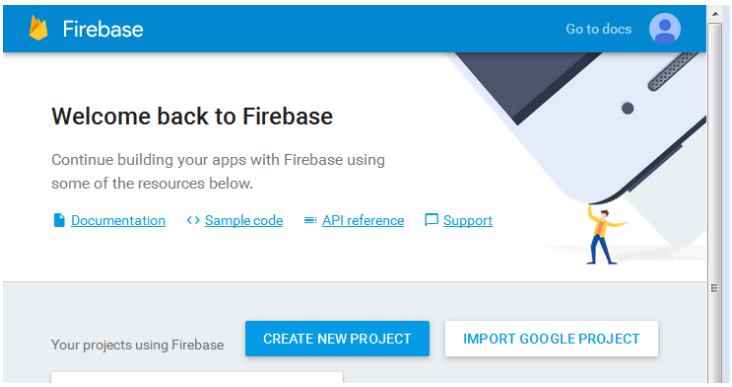
equation String
xCCCSSyCySSSCySSSMMASSS
xCSxxSCMCyQCSAASSxMC
xxSyyAMSxCQSAMCQxSSCMQC
yCQyCxCAMCSCCCxCCCSMS

Firebase

- Yet another Backend as a Service (BaaS):
  - **"Firebase** is a real-time cloud data service. Firebase database is stored as JSON and synchronized in real time to every connected client. When you build cross-platform apps with our Android, iOS, and JavaScript SDKs, all of your clients share one Firebase database and **automatically receive updates with the newest data"**
- Designed for web and mobile
- Founded in 2011
- Initial product was backend so websites could easily host chat as part of site
- Discovered developers were sending non chat data (such as game state) via the tool

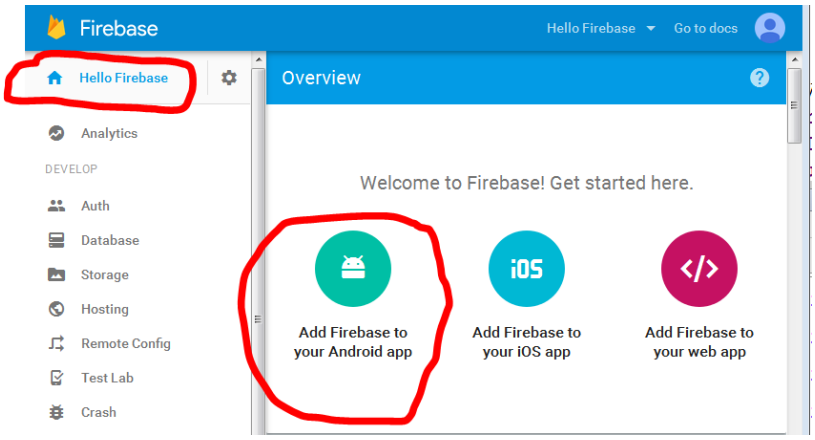
Firebase

- Create Firebase project in console
- Just needs name and country

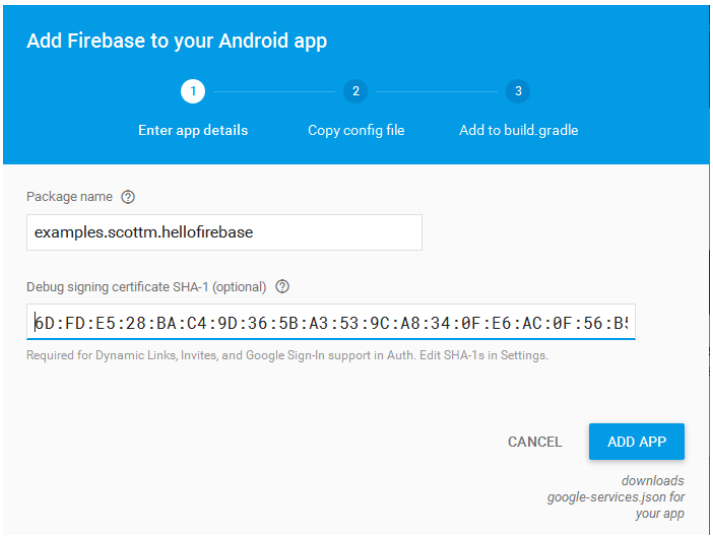


Firebase

- After creating project, overview page:

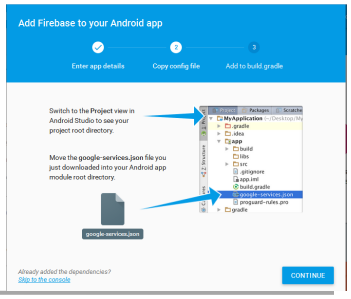


Firebase



Firebase

- After providing package name and SHA-1 fingerprint ...
- Firebase generates a JSON file named google-services.json specific for this project
  - multiple projects / apps -> repeat steps
- Download and add file to project
- Update gradle file



Firebase

- Documentation:
- https://firebase.google.com/docs/?authuser=0

- Capabilities:
  - User authorization
  - Database storage
  - Storage for larger files
  - Cloud messaging
  - Push notifications
  - Analytics
  - Hosting of web content
  - …

	Firebase	Parse Server
General Purpose	Fast real time updates (Real time BaaS)	Open source
Hosting	Google hosting. Free up to 100 simultaneous connections .	Self hosting and Parse hosting providers. No limits. Supports Local testing and developing
Custom Code	Custom code not supported	Custom code totally supported(Cloud Code)
Database	Supports model observer scheme. Now introduced Firebase Storage to upload and download files securely	Has huge relationship based databases
Push	Support Push notifications. Firebase Remote Config to customize apps	Support Push notifications for Android, iOS. Also it is possible to send Push Notifications campaigns.
Setup	Easy setup	Quick setup on Parse Easy step by step set up guide available for migrating from Parse to Parse Server
Storage	Stores data as JSON and data backup can be uploaded to Amazon S3 bucket or Google cloud storage	No restricted time limits and No file storage restrictions. Control over backup, restore, database indexes.
Provider	Developed by Google	Developed by Facebook
Ideal for	Suitable for time applications	Suitable for building general purpose applications

Alternatives

- https://github.com/relatedcode/ParseAlternatives

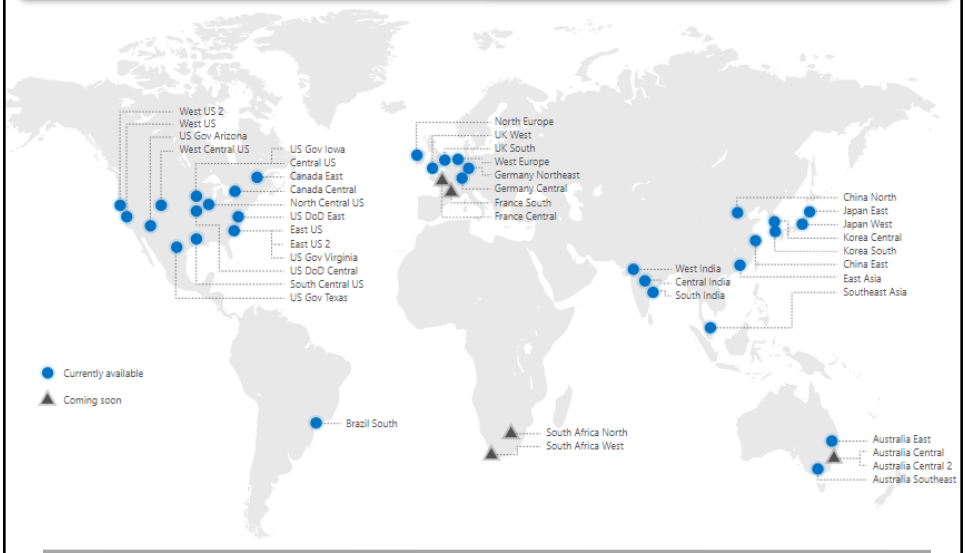
Choosing a MBaaS

- Ease of Use (Parse, Back4app)
- Automated updates (Firebase)
- Analytics (User data, crashes)
- Authentication (including social media integration)
- App/Database management
- Push notifications
- Cloud code, background jobs
- System emails (password reset, verification)
- Variety of APIs (iOS, Android, REST)

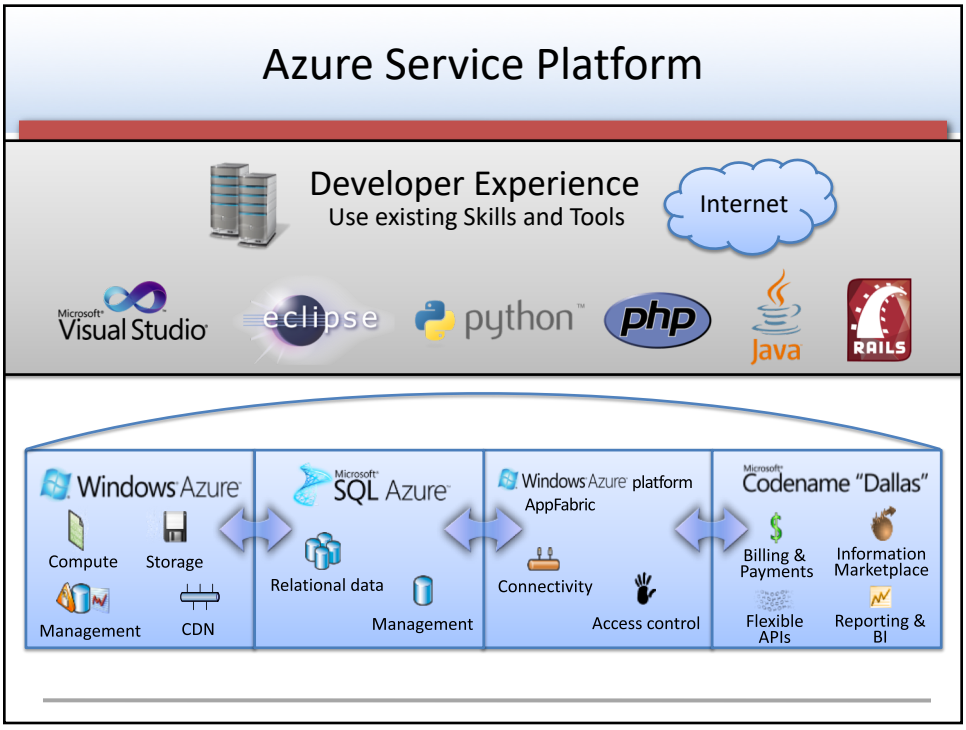
Cloud Computing: Microsoft Azure

- Comprehensive set of cloud services (IaaS/PaaS)
- On-demand services hosted on Microsoft Data Centers

Cloud Computing: Microsoft Azure



Azure Service Platform



Pay-As-You-Go

Small	Medium	Large	X-Large
$0.12	$0.24	$0.48	$0.96
Per service hour	Per service hour	Per service hour	Per service hour

Unit of Compute defined

Equivalent compute capacity of a 1.6Ghz processor (on 64bit platform)

Small	Medium	Large	X-Large
1 x 1.6Ghz (moderate IO)	2 x 1.6Ghz (high IO)	4 x 1.6Ghz (high IO)	8 x 1.6Ghz (high IO)
1.75 GB memory	3.5 GB memory	7.0 GB memory	14 GB memory
250 GB storage	500 GB storage	1,000 GB storage	2,000 GB

Other Providers

- Amazon Web Services (AWS)
  - Amazon Simple Queue Service (SQS)
  - Elastic Compute Cloud (EC2)
  - Simple Storage Service (S3)
  - Many more…
- Google Cloud Platform
  - Compute Engine (IaaS)
  - Google App Engine (PaaS)
  - Cloud AI
  - Google BigQuery