Introducing cloud computing for research

Practical Introduction for Researchers using Microsoft Azure for the MSU Cloud Computing Fellowship

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Part 1: the "computing" in cloud computing

Fellowship Goal: help you connect cloud computing to your research in a meaningful way

our original question:

- How can *cloud computing* benefit help your research?

Let's re-frame the question for this discussion:

- Which kind of *computing* could help my research?
- Can I find support for that kind of computing using *cloud* services?

What is computing? Computing Vocabulary

- cloud computing is marketed to IT systems administrators, software developers, and managers -- not for us (unless you are a systems engineer).
- The primary function of cloud computing is to provide "infrastructure" aka the "back-end" or back room of a company's IT department, so we ware going to learn about that.
- cloud computing is defined and sold based on abstractions of physical components of computers and other infrastructure such as network.
- Learning about IT infrastructure may be helpful understanding the

What is computing: Major components of computer

- User software (scripts, user code, etc)
- Base Software
- Operating System
- Input/Ouput (I/O)
- Central Processor (CPU) & Memory (RAM)
- Computer Architecture (model type)
- Storage - local disk
- Storage - external (attached or via network)
- Network

What is Computing: What is a server?

Cloud computing is all about "servers," so we should define that.

A server is any computer connected to a network, running software that listens for, and responsed to, messages

- The 'server' is actually the software, not the hardware
- The computer that runs the software is the 'host'
- A 'client' is software sends the message, and receives and interprets the response.
- the form the message can take is the API.

What is Computing: Example Server: Web server?

- client is the web browser
- message = URL which includes address, url paths, and additional parameters
- response = the code for the web page
- client interprets the code and renders the page.
- an alternate client could be a script, or the `curl` utility
- `https://www.amazon.com/dp/B09VXBNTJ1/ref=sr_1_93?brr=1`

What is Computing: Data Server Example

- Client: special database client (not web browser)
- message : insert these 5 rows of data
- response: `inserted 5 rows`
- message: select rows of students in Math 101
- response: data such as

```
"First Name","Last Name","Email","Level"
"Lucy","Grant","l.grant@randatmail.com","7"
"Emily","Russell","e.russell@randatmail.com","5"
"Annabella","Ferguson","a.ferguson@randatmail.com","8"
etc
```

What is Computing: Servers and Networks

Networking Requirements to access a server:

- the server must be on the same network as you to receive your message
- the more accessible the network, the more vulnerable, so partitioning is used
- servers that accept messages from the Internet are a major security risk
- network failure stops all work for everyone
- designing efficient, robust, and secure networks is a major resource drain

Too much hardware : Virtualization to the rescue

IT Departments for institutions 'serve' large user communities with large amounts of infrastructure (hardware, networking, data centers, power, etc) Techniques were invented to seperate the 'server' or 'network' from the hardware.

Virtualization: single box with a layer of software to share among different software.
Software-defined networks:

- Many servers could be created and managed with software on a single hardware
- Virtualization was a necessary conceptual and technological

Part 2: Origin of Cloud Computing:

Some Motivation at Amazon.com

- Massive IT infrastructure supports the Amazon store and company
- They wanted to sell shopping application as a service to a company like Target who didn't want to run their own store. T This required the software developers to have lots of flexible infrastructure (servers) to run on.
- They found team to build a service (with software) could spend 70% of their time setting up the 'back end'
- They called all the infrastructure needed to run a massive dot-com "muck" and saw this as a secondary supporting role to application development. What they wanted in days actually took months.

Eureka moment for Amazon: we could sell it

- Amazon automated their IT department so teams could order and provision the servers they needed on demand beyond just virtualization ("everything was an API")
- They got really good at running very large data centers for many customers as cheaply as possible and on-demand for Amazon.com and other stores and services.
- They realized that their innovations would help any IT organization and especially internet start-ups like themselves, and that they could sell it.
- Their customers were other IT departments
  Blog Post from 2006: "We Build Muck, So You Don't Have To"

NIST defintion of cloud

Government offices interested in purchasing cloud computing needed a definition of it to differentiate from other kinds of computing, hence... the [NIST definition of cloud computing] essential characteristics

- **On-demand self-service**.
- **Measured service**: pay for what you get.
- **Broad network access**: accessible from the internet
- **Rapid elasticity**: no limits from a customer perspective. This word was invented by AWS
- **Resource pooling**: single resources serve many customers.

What is Cloud Computing? Cloud concepts vs Cloud Providers

- Three major cloud providers are in a constant arms race, literally (*Azure vs. Amazon competed for a $10B defense contract*): Azure, Amazon Web Services and Google Cloud Platform
- Offerings are very similar so all are great choices
- other options, smaller companies, open source options (used by Indiana University JetSteam HPC, Osiris project from MSU, UMich, Wayne State and IU. Cyverse for running jobs.

Benefits of Cloud Computing for Research

- Customized Computing: can create customized resources only when you need it
- Elastic/On-demand: can run ad-hoc computations on those on-demand resources
- Instant service:
- Reproducible: a computation can be re-run as needed, meaning cloud resources can be easily re-recreated to re-run your computations.
- Cost effective: unlike commerical applications, more users does not mean more revenue. Budgets are fixed and the pay-as-you-go model requires vigilance to not over-spend.

Benefits of Cloud for Research

Restatement of goals of this fellowship:

- Learn which types of computing resources are beneficial to your research
- Learn how to use Cloud to create those resources
- Use the services packaged by cloud companies to discover new resources

Learning how to learn about cloud

- Training materials and documentation is written for IT professionals

- Our goal as researchers is to get our work (or the work of our lab) done, not to build systems used by hundreds of people or for business purposes. <!-- That can make it difficult to decipher which kind of cloud service will work best for your use case.
- As Dr. Parvizi writes, cloud is very different from using traditional research-oriented technology like workstations or HPC. - There are hundreds of services to choose from but we find many researchers will reach for the conceptually straightfoward path of creating cloud computers and install what they need.

What documentation *is* available for researchers?

There are general, conceptual introductions and dicussions for academics.

- https://cloud4scieng.org/ Book and website from Ian Foster and Gannon (U. Chicago), the text used for this fellowship.
- https://cloudmaven.github.io/documentation/ from the eScience institute of the University of Washington. It doesn't appear to be maintained but may have some good resources. Original github repositories are https://github.com/cloudmaven
- https://cloudbank-project.github.io/cb-resources/ Seems to be a succesor to the 'cloudmaven' documentation above as members from cloudmaven are contributing here.

Learning how to learn about cloud: Caveats and help

As part of this fellowship, our goal is to help you translate documentation written for the systems and developer perspectives into a research perspective.

- The cloud services themselves are always changing
- There are new services and bundles created all the time that may be competing or superior choices for doing research
- If you are unsure, ask us. See the contact page or use our Teams channel.
- Cloud companies have help desks and many resources for anyone using their services or potential customers and we may be able to

Theme: Using workflow and computational thinking

- Karl Popper stated that "non-reproducible single occurrences are of no significance to science" (*K Popper, "The Logic of Scientific Discovery", English translation from Routledge, London, 1992, p. 66.*) and this is a significant issue for research based on computing

- A major advantage to using workflows or code for provisioning your cloud computing components is that you can turn them off and delete them when you are done, and restart when needed. .
  -Our first uses of cloud will use forms to create resources, but we encourage you to automation where possible

About Cloud Security

Security and Risk management is an important issue even for researchers who's data may not be sensitive or even open source.

- Finding a readable list of security recommendations for cloud computing is a challenge for all the reasons outlined above. Our textbook has a nice chaper outlining cloud security
- If your computer is a **server**, your responsibility just increased 100X as these are primary targets for hacking. Consider each component of a server to be a point of vulnerability.

Costs and Budget overview

- Each participant has a budget for their Azure resources.
- If you need to use Google or AWS we need to make additional arrangements but your first step would be to acquire a free starter account with these companies (e.g. using a gmail address).
- Costs are more than just dollars for services. Consider `[Total Cost] = ( $ + Time + Risk )`
- `[Total Time] = ( development time + wait time + compute time )`
- Security Risks are rarely non-significant, so factor that into cost

HPCC vs Cloud

- Dr. Parvizi's white paper outlines the challenges of adapting HPC workflows to cloud computing.
- The HPC is amazing effective at running all kinds of systems at very list cost, if any, to MSU researchers, but not all are the best fit
- Many systems not designed for HPC can be adjusted to run in that environment. However, just like many workflows are difficult to port from HPC to cloud, some cloud workflows are difficult run on HPC (but never say never). Especially windows-based software.
- I will cover some of these types of systems in future sessions

Acknowledging bias in access to cloud computing across research cultures

It's widely recognized that AI is frequently bias. For example, Azure Voice recognition did not work for a female researcher who developed voice-controlled surgery, so

- There is inherent bias in the interfaces, design and definitions in the engineerig of technology in terms of gender, culture, and background. System Engineering is it's own discipline and Cloud computing is arcane
  -our goal is to reduce conceptual barriers to using this technology

Additional comments from instructors and organizers

Source Materials

https://softwaresim.com/blog/introduction-to-cloud-computing-for-research/