Your Nebulous Navigators

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Nebulous comes from the Latin nebulosus, "cloudy, misty, or foggy." Its root is nebula, which is "vapor or fog" in Latin and was adopted by astronomers in the 1700s to mean "a cloud of gas and dust in outer space."

Our Cloud Decisions Matter

2700 colocation centers across the U.S. consume vasts amounts of electricity and water, but provide very few human jobs required for operation. And, many of which are located in areas that are susceptible to drought.Anywhere from

3 to 5 million gallons of water a day is required.

(Enough for 30,000-50,000 people)

In the U.S., data centers consume 200 TWh (Terawatt Hours) annually and dump 0.3% of CO_2 emissions into the atmosphere. That is more energy consumption and CO_2 emission than some nation-states.

Data center **emissions are expected to rise and surpass those of the airline industry**, which currently accounts for 2% of global GHG emissions.

Source: 8 Billion Trees

Higher education's shift from legacy servers to cloud computing is not just modernization—it's a revolution.
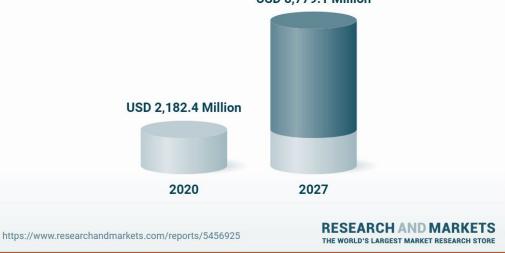
From effective collaboration and scalability, to bolstering cybersecurity and perceived cost savings, the cloud propels academia into a nimble, data-driven future.

The global **Cloud Computing in Higher Education** market held a market value of USD 2,182.4 Million in 2020 and is forecasted to reach USD **8,779.1 Million by the year 2027**. The market is anticipated to register a CAGR (Compound Annual Growth Rate) of 22% over the projected period.

Global Cloud Computing in Higher Education Market

Market forecast to grow at a CAGR of 22.0%

USD 8,779.1 Million

USD 2,182.4 Million

2020

2027

https://www.researchandmarkets.com/reports/5456925

RESEARCH AND MARKETS
THE WORLD'S LARGEST MARKET RESEARCH STORE

Source: Research and Markets

A recent *Inside Higher Ed survey* revealed **45% of student respondents** considered environmental sustainability in their college enrollment decision. In addition, almost twice as many (85%) think prioritizing sustainability is at least somewhat important.

According to the 2022 Forrester Consulting report, leaders at 105 schools said **45% of student respondents knowing students might choose their institution based on sustainability values is the biggest driver for showcasing and advancing environmental commitments.**

Higher ed's digital future hinges on tech sustainability. It's not just a choice - it's our responsibility.

Measurement

Just like meteorologists need measurements to forecast storms, **technologists must quantify their environmental impact for effective sustainability.** This groundwork guides informed, impactful actions for a greener tech.

Action

A spotlight on actionable strategies based on measurement, with real-world case studies from Rob and Keith.

Community

Power in numbers: the Internet2 cloud and sustainability community.

Guidance from the Nimbus with
Rob Carter

Duke

A nimbus is a type of cloud that is capable of producing precipitation, such as rain, snow, or other forms of moisture. The term "nimbus" is often attached to other cloud names like "nimbostratus" for low-level, continuous precipitation clouds and "cumulonimbus" for taller, stronger weather-producing clouds.

First Reactions:

- This isn't my area of expertise. (if I even have one of those)

- Duke isn't on the fast track to move to "the cloud", really

NOT QUITE SURE WHAT I AM DOING HERE

Only you can prevent forest fires...

Realizations:

- This isn't *our* area of expertise. That doesn't matter.

- What we're doing on prem *probably* follows what cloud providers are doing. May be some learnings there.

- Relativity theory ftw: How can we say "X is greener" without quantifying how "green" not-X is?

Want Measurement? *Follow the Money*

Why do we even consider cloud services in the first place?

- Hope for reduced TCO ($$)

- Services and features we can't afford otherwise ($$)

But, I thought we were talking about the environment?

- $$ track resource usage (usually)

- Resource usage tracks environmental impact (mostly)

- Variable costs in computing tend to connect with environmental impacts (fixed overhead not so much)

Power and Cooling and Power
(oh my!)

Amortized Overhead - Capital HW, HR, Real Estate

Direct Costs - Maybe Mutable

- **POWER - Moar MIPS = Moar Watts**

  - It matters how we generate electricity: Burning dead tree-ferns, splitting atoms, capturing sunlight

- **COOLING - Physics is no one's friend**

  - We pay twice for every Watt we use – once for making it, and once for dissipating the heat it inevitably produces

- **POWER - Thermodynamics ftl**

  - When we need to dissipate heat, we usually have to expend energy to violate the Second Law
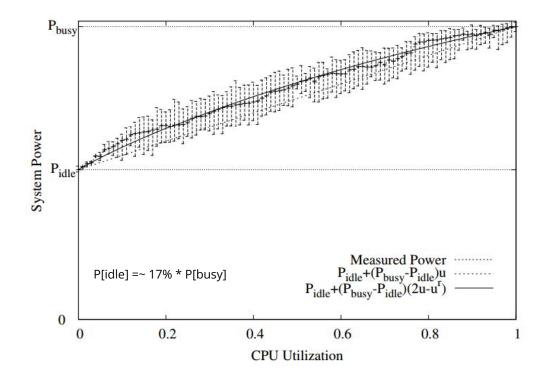
Efficiency

What we *can't* do (most of the time)
- Fight physics. Maybe a little Aikido…
- Control demand. We're providers, not consumers.

What we *can* do (most of the time)
- Make the most of every dead tree-fern - amortize overhead over as much real work as possible
- Remember it's not just computing - storage devices use power, too!
- The most secure computer is the least environmentally impactful computer :-)

P[idle] =~ 17% * P[busy]

$$\text{Measured Power} \cdots\cdots$$
$$P_{idle}+(P_{busy}-P_{idle})u \quad \text{-----}$$
$$P_{idle}+(P_{busy}-P_{idle})(2u-u^r) \quad \text{———}$$

What we *may* be able to do (some of the time)

Make green choices about facilities planning

Measure, Measure, Measure

Duke Advantages

Duke School of the Environment

Senior C-level support for Net-0 by Q4 2024

- Sustainable Duke; Solar Plant; Carbon Offsets; Sustainability czarina
- Facilities Management committed to transparency
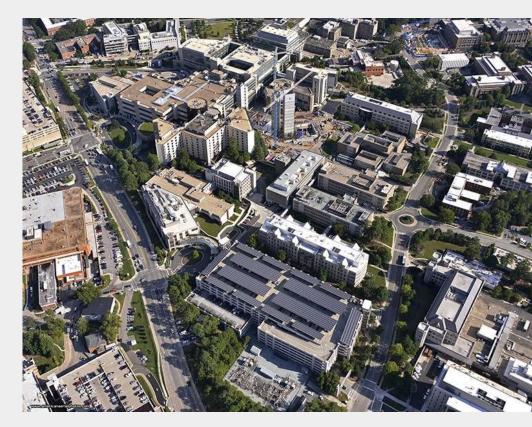
Location, location, location

- Duke Power 40% nuclear, 5% solar/wind and growing

Timing

- On-prem DC redesign < a decade past
- Site-wide chilled water facility came online at just the right time

HR advantages

- Excellent development staff -> Good automation tools
- Excellent monitoring group

Solar collectors atop Duke Hospital parking deck

Duke: On-Prem Strategies - Clean ur Plate

- **Duke employs cloud provider strategies locally to save $$**

  - Box-packing research computing loads; "scavenger queues" -> ~ 100% cpu occupancy

  - **Heavy** virtualization - not just CPU/memory, but also GPUs -> higher efficiency

  - Multi-generational HW - get density, power efficiency advantages incrementally

  - Dynamic work cycles - power it off when not in use strategy

    - Student virtual resources reserved 1 semester at a time, default to powered off after 24 hours

    - Course computing resources containerized - highest possible density / HW, "spun up/spun down" as used

- **Savings in $$ relates to savings in sustainability**

  - HPC, virtual lab computing is striving for 100% occupancy – mostly > 90% utilization

  - We save portion of the ~ 15-20% "overhead" cpu + gpu utilization

Duke: Cloud Bursting and Alberta Clippers

Three directions

- **Special purpose computation**
  - Sometimes researchers need **way** more hardware than we can deliver locally
  - **Usually** these are short-lived requirements
  - **Unfortunately** they tend to require reserved resources - cloud ftw
- **Burst mode computing**
  - 300 Chem students with assignments due at midnight
  - More work to be done, but angling toward using spot-market computing
  - Duke becomes the "scavenger queue" user for cloud services
- **Research data lifecycles**
  - Spinning rust / powered-up flash / on-prem storage **during research effort**
  - Ship to low-cost, **probably offline** storage for archiving
  - Disks use less power when they're not powered on

Wisdom in the Cumulus with
Keith Wessel

UNIVERSITY OF
ILLINOIS
URBANA-CHAMPAIGN

A cumulus cloud is a type of cloud that is often large, white, and fluffy with a flat base. They are typically associated with fair weather but can grow into larger storm clouds. Cumulus clouds form as a result of vertical convection currents caused by warming at the Earth's surface.

What if it's not your data center?

- Choosing the right cloud provider.

- In addition to considering cost and services.

- Where do they get their power?

  - Clean energy like solar and wind?

- How do they manage cooling?

- What energy-saving options do they offer customers?

- Illinois didn't consider these options early on…

  - But we're starting to ask them now.

- **And there are plenty of choices you can make, too.**

Choice 1: What do I need to remember?

- Cloud services are easy to spin up

- And easy to forget to shut down

- Case: researcher sandboxes

  - Used once then forgotten about

  - Still using energy and costing $

- Set them to auto-delete or archive

- Owner must take action to keep them around

Choice 2: How much power does it need?

- Auto-scale services
- Case: Illinois' Shibboleth IdP
  - Needs lots of CPU during semester
  - Not so much during winter break
- Service launched with 5 nodes
- Auto-scale down to 1 when nobody's using it
- Trick is finding metrics to scale on

Choice 3: Does it need to be running?

- Got a service only used occasionally?

- Case: Illinois IAM team management box

  - EC2 box used to manage services

  - Maybe used 5-10 times/week

  - Why pay to keep it running?

- Shut it down until needed

- **Better yet, delete it altogether**

  - Can re-create quickly with Terraform

  - Store stateful data externally

  - Bonus: it's always patched!

Choice 4: Does it *need* a server at all?

- Consider serverless
- Case: lightweight web applications
  - We all run lots of these
  - They sit around burning energy
- Make it serverless
  - Let it spin up on-demand
  - No energy at all other times
- How crazy do you want to get with this?
  - Our director wants a serverless IdP

Choice 5: How do you keep it running better?

- So you say you need a server
- And you need to keep it up all the time
- Consider a less hungry CPU
  - ARM processors are catching on
  - Amazon calls them Graviton
  - Others have other brandings
- They use less power
- They generate less heat
- Illinois IAM team considering uses
  - Shibboleth nodes
  - Various web services
  - And that EC2 management box

Cirrus-ly, What's Our Next Move?

A cirrus cloud is a high-altitude cloud that usually appears white and is often seen in fair weather, but can also indicate that a change in the weather is coming. These clouds are thin and wispy, typically forming above 20,000 feet, and are composed of ice crystals due to the cold temperatures at high altitudes.

We're (literally) not trying to boil the ocean.
We can all play a small part to move forward in the right direction.

Measurement

Find areas you can measure in your respective areas. **Start small**.

Action

Use Rob and Keith's experiences as inspiration to get started. **Find out if your university has a sustainability commitment**, and whether tech is factored into that plan. Explore your cloud provider's practices.

Community

Join the **I2 Cloud Group Slack** and contribute to the conversation.

Your voice matters.

**Join the [higher ed Cloud Computing Community Group (CCCG) Slack workspace](#) and get involved with the #cloud-sustainability channel.
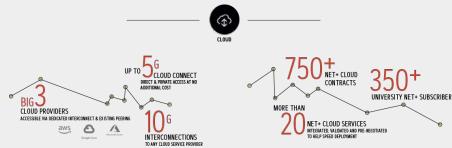We'll post the slide deck and additional resources.**

Get involved with the Internet2 Cloud community

Internet2 Community Exchange, internet2.edu/2024-internet2-community-exchange/

March 4-7, 2024 | Chicago, Ill.

The Internet2 Community Exchange returns in spring 2024 for another highly-anticipated in-person convening of the research and education (R&E) community. Internet2 is again bringing focus to an exchange of ideas at its annual spring conference, facilitating new and fresh thinking and purposefully engaging a more diverse audience of R&E professionals across both long-standing and new community participants. This includes a focus on addressing the inclusion of under-served institutions and the knowledge base new participants bring to our global community.

CLOUD

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The Cloud Forum, internet2.edu/cloud-forum/

April 30 to May 2, 2024 | Stanford University

The Higher Education Cloud Forum is a gathering for higher education IT professionals to discuss the challenges, potential, and best practices for using hyper-scale computing tools and platforms to support enterprise computing, and academic research, as well as teaching and learning. The event is created by higher ed, for higher ed.

Questions? Contact Bob Flynn, bflynn@internet2.edu

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Connect with us during and after TechEX!

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