



# The End and the Beginning

**Tim Cartwright**

*OSG Deputy Executive Director and OSG User School Director  
University of Wisconsin–Madison*



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# The End...



# **We must adjust to changing times and still hold to unchanging principles.**

- Attributed to former U.S. President Jimmy Carter, who attributed it to his high school teacher, Julia Coleman



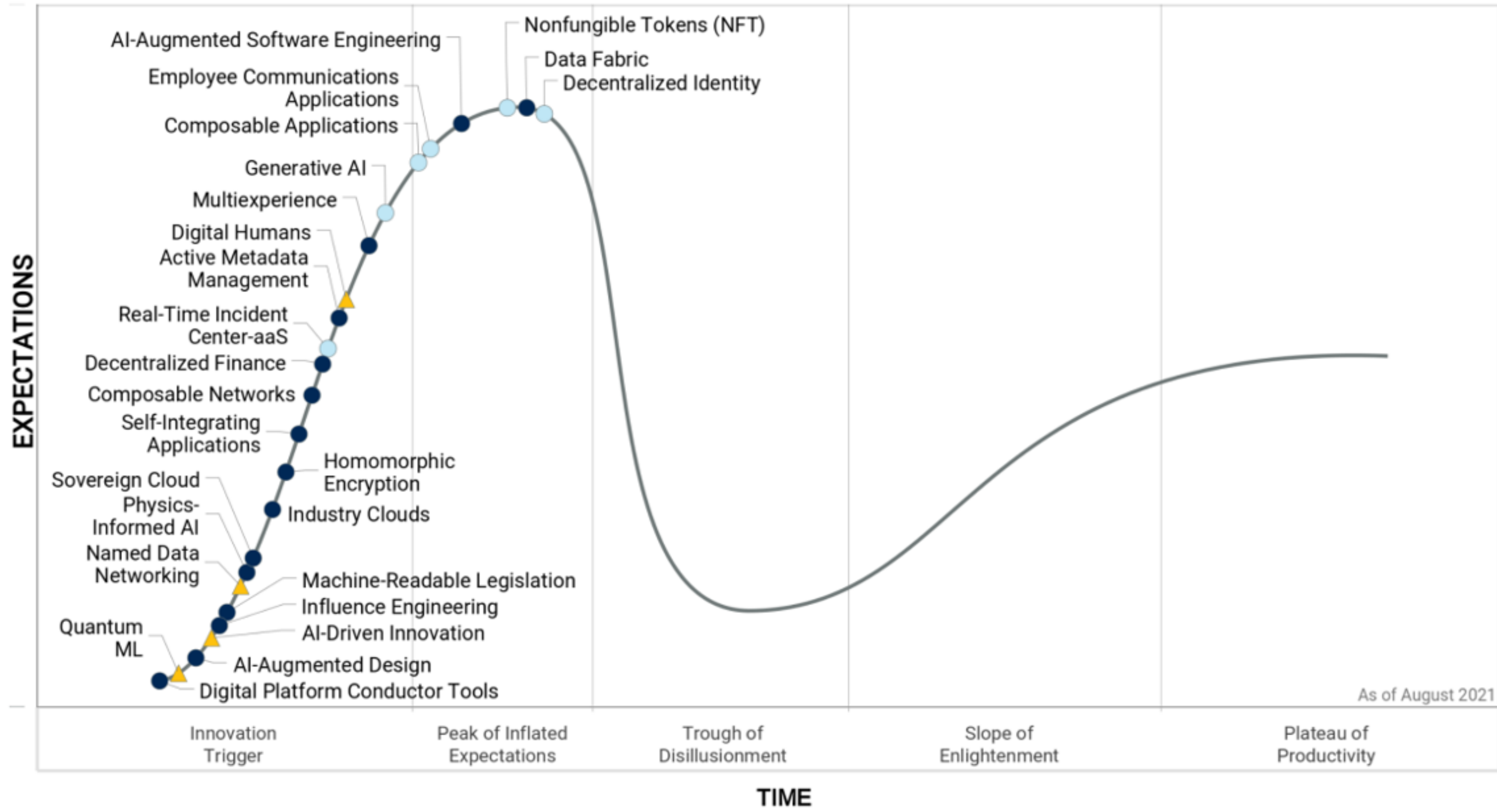
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*Why?*





# Gartner Hype Cycle



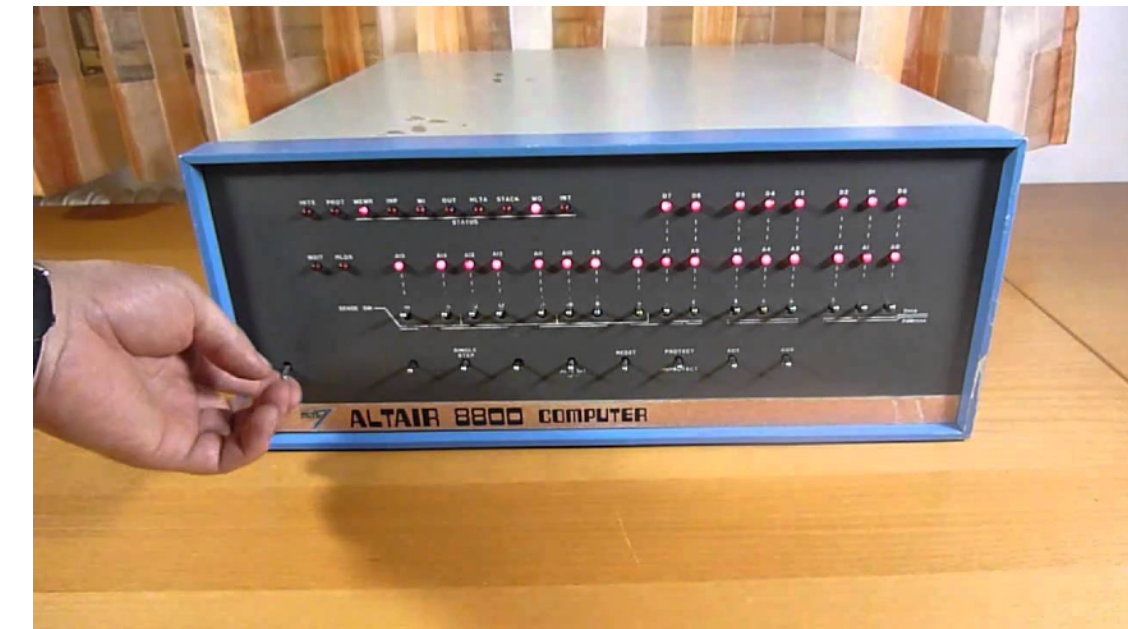
Plateau will be reached: ○ < 2 yrs. ● 2-5 yrs. ● 5-10 yrs. ▲ >10 yrs. ✗ Obsolete before plateau

Source: <https://emtemp.com.cloud/ngw/globalassets/en/newsroom/images/graphs/hc-emerging-tech-2021.png>



# Recent Paradigm Shifts

**1970s** Computing capacity packaged and sold in small units



**2000s** Computing capacity available to lease by the minute



**BUT:** Principles haven't changed with these shifts!



# A Brief History of HTC

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1983	Miron Livny completes Ph.D. thesis
1985	First Condor deployment
1992	Completed run of 250,000 jobs
1994	LHC approved
1996	Introduced "High Throughput Computing"
2000	Start of Trillium project (PPDG + GriPhyN + iVDGL)
2004	Start of EGEE (Enabling Grids for E-science)
2005	Start of Open Science Grid
2009	LHC Run 1 begins
2010	<i>Perspectives on Grid Computing</i>
2010	Start of EGI (née European Grid Initiative)
2012	LHC detects Higgs boson
2015	LIGO detects first binary black hole merger
2017	First release of HTCondor Annex, to work with clouds
2022	PATH Facility deployed

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# Some Principles



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# ***#1: Unity and Autonomy***





# Two Principles of Distributed Computing

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- **Unity:** Parts of system try to reach common goal
  - Goal determines rules that control independent parts
  - E.g., OSPool resources should always be running jobs
- **Autonomy:** Parts are autonomous but cooperate
  - One part can refuse a request from other part
  - E.g., a resource provider (site) can turn away pilots
- **There are always trade-offs**



# Autonomy => Ownership

- In 1985, HTCondor added the idea of *resource ownership* as a key extension to prior work in distributed computing
- Resources have owners, and those owners must have the ability to decide how their resources are used... or else!







# HTC Is Sharing

- Should I share my resources and, if so, with whom and when?



- “HTC is about sharing across many **jobs**, many **users**, many **servers**, many **sites**, and (potentially) long-running **workflows**.”
  - Miron Livny





# Sharing Leads to Community

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**“Now you have  
a community of customers  
who are motivated to share and  
act as consumers, providers, or both.”**

*– Miron Livny*



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# ***#2: Automation***



# HTC Needs Automation

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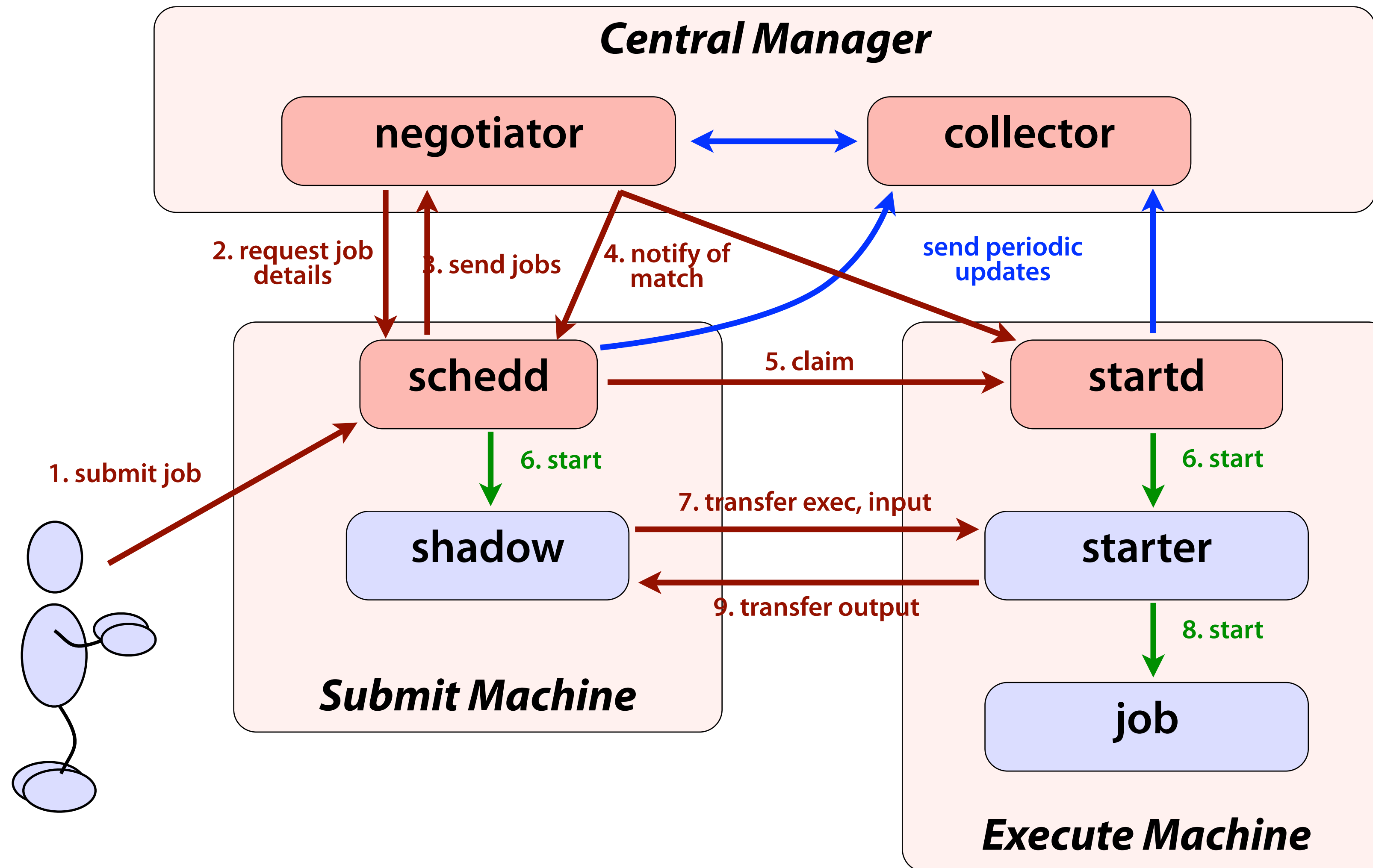
HTC requires **automation**,  
as it is a 24-7-365 activity that  
scales well beyond human interaction

**FLOPY  $\neq$  FLOPS  $\times$  (60 $\times$ 60 $\times$ 24 $\times$ 365)**

**1 job  $\times$  100 KHrs  $\neq$  100K jobs  $\times$  1 Hr**

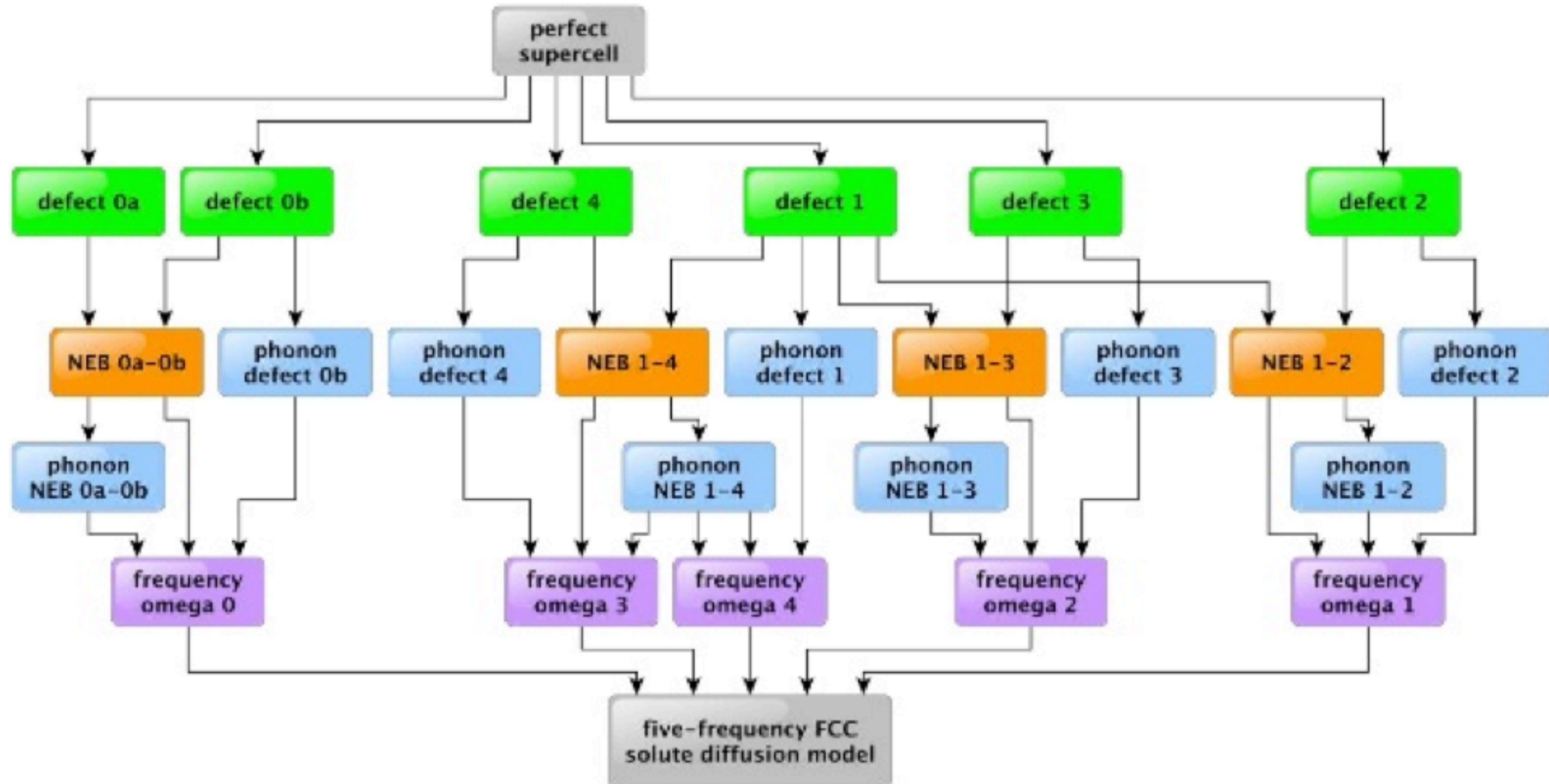


# Automation I: Get Resources & Run Jobs





# Automation II: User Workflows



Source: Professor Dane Morgan, University of Wisconsin–Madison





# Automation II: System Maintenance

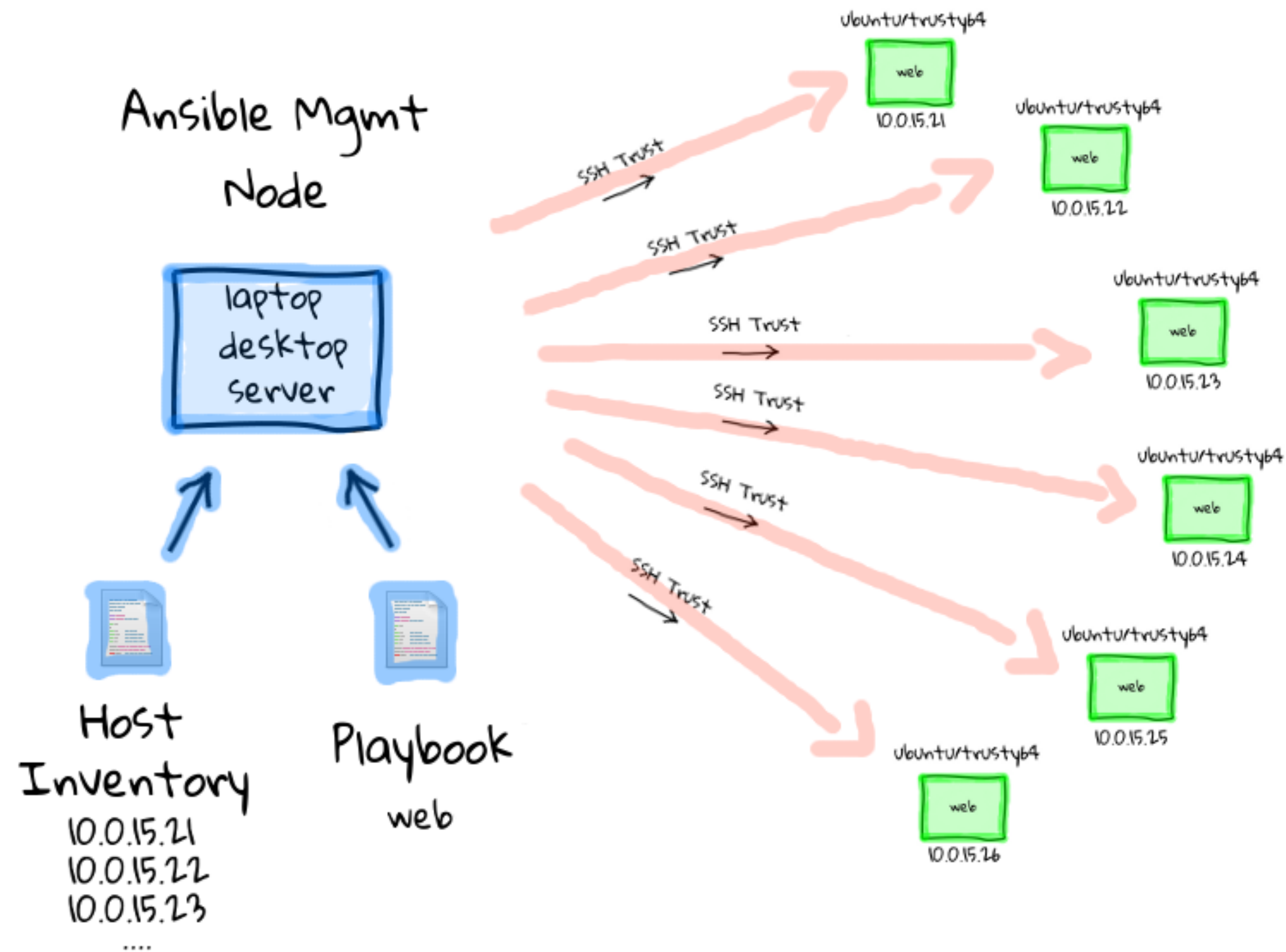


Diagram: Justin Weissig, <https://sysadmincasts.com/episodes/43-19-minutes-with-ansible-part-1-4>



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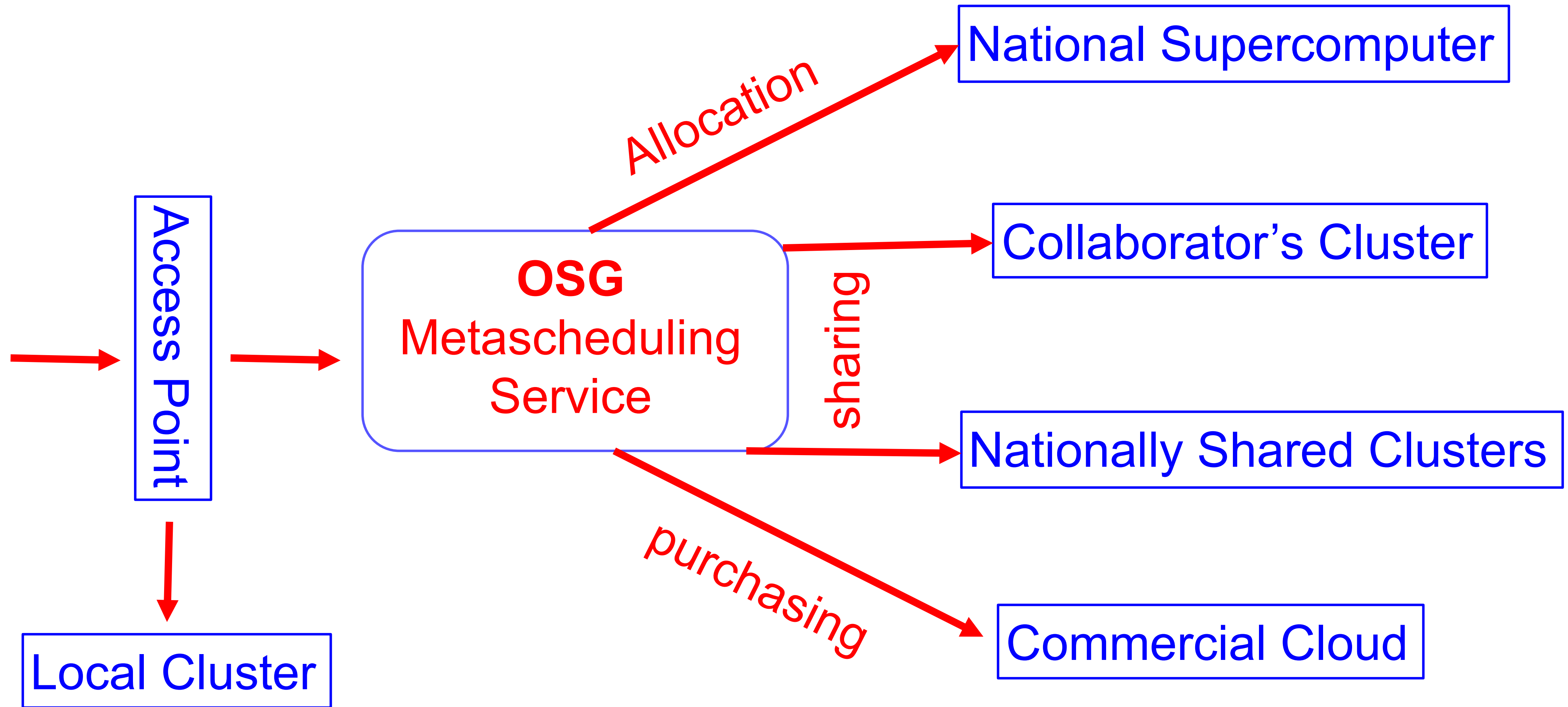
# ***#3: Submit locally, run globally***





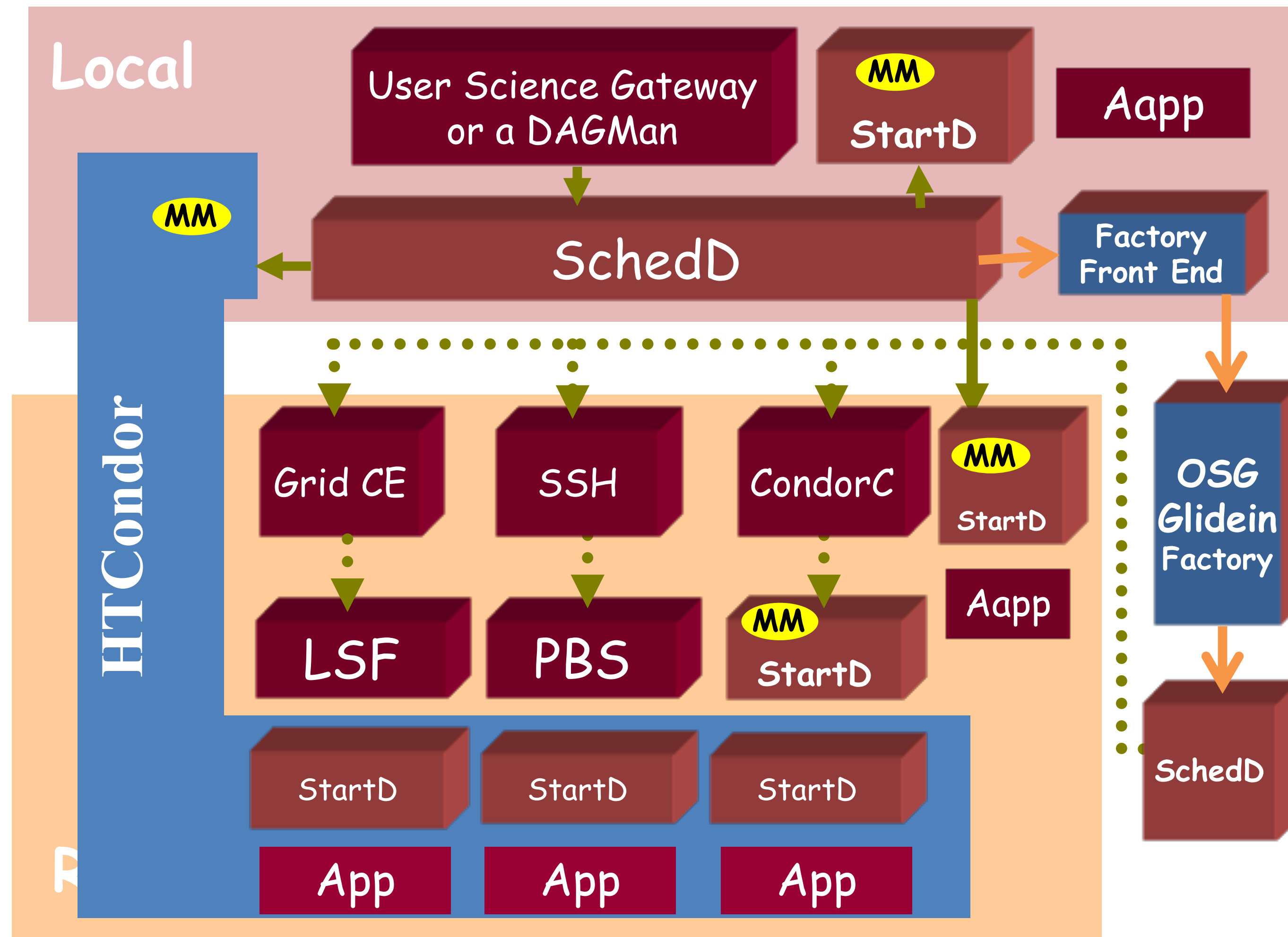


# OSG Is Getting There...





# ... But It Is Still Complex ...







# ... and Takes a Lot of Care

Local site osgmon, check_mk							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	hcc-gracc-apel-itb.unl.edu		22	1	0	0	0
UP	hcc-oasis-itb.unl.edu		25	0	0	1	0
UP	hcc-oasis-login-itb.unl.edu		27	0	0	0	0
UP	hcc-osg-collector2.unl.edu		19	0	0	0	0
UP	hcc-osg-collector.unl.edu		20	0	0	0	0

Local site osgmon, collectors							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	collector1.opensciencegrid.org		22	0	0	0	0
UP	collector2.opensciencegrid.org		20	0	0	0	0

Local site osgmon, cvmfs							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	hcc-cvmfs2.unl.edu		28	0	0	0	0
UP	hcc-cvmfs-repo.unl.edu		59	0	1	2	0
DOWN	hcc-cvmfs.unl.edu		29	0	0	2	0

Local site osgmon, frontends							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	flock.opensciencegrid.org		32	0	0	0	0
UP	gfactory-2.opensciencegrid.org		22	1	0	0	0
DOWN	glidein2.chtc.wisc.edu		0	0	0	2	0
DOWN	glidein3.chtc.wisc.edu		0	0	0	2	0
UP	glidein-frontend-2.t2.ucsd.edu		22	0	0	0	0
UP	glidein.unl.edu		23	0	0	0	0
UP	osg-bnlvo-1.t2.ucsd.edu		0	0	0	2	0
UP	osg-gluex-1.t2.ucsd.edu		21	0	0	0	0
UP	osg-ligo-1.t2.ucsd.edu		21	0	0	0	0

Local site osgmon, gracc-elastic							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	gracc-data1.anvil.hcc.unl.edu		21	0	0	0	0
UP	gracc-data1.opensciencegrid.org		21	0	0	0	0
UP	gracc-data2.anvil.hcc.unl.edu		21	0	0	0	0
UP	gracc-data2.opensciencegrid.org		21	0	0	0	0

Local site osgmon, hosted-ce							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	hosted-ce04.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce07.grid.uchicago.edu		0	0	0	1	0
UP	hosted-ce08.grid.uchicago.edu		0	0	0	1	0
UP	hosted-ce10.grid.uchicago.edu		0	1	0	0	0
UP	hosted-ce12.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce13.grid.uchicago.edu		0	1	0	0	0
UP	hosted-ce14.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce15.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce16.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce18.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce19.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce20.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce21.grid.uchicago.edu		1	0	0	0	0
DOWN	hosted-ce22.grid.uchicago.edu		0	0	0	1	0
UP	hosted-ce23.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce24.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce25.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce26.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce27.grid.uchicago.edu		0	1	0	0	0
UP	hosted-ce28.grid.uchicago.edu		1	0	0	0	0
UP	hosted-ce29.grid.uchicago.edu		1	0	0	0	0
UP	pearc-ce-2.grid.uchicago.edu		1	0	0	0	0

Local site osgmon, oasis							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	hcc-oasis-login.unl.edu		27	0	0	0	0
UP	hcc-oasis.unl.edu		26	1	0	0	0
UP	oasis-itb.opensciencegrid.org		24	1	0	0	0
UP	oasis-login-itb.opensciencegrid.org		27	1	0	0	0
UP	oasis-login.opensciencegrid.org		26	1	0	0	0
UP	oasis.opensciencegrid.org		25	2	0	0	0

Local site osgmon, repo							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	hcc-osg-repo.unl.edu		24	0	0	0	0
UP	hcc-osg-software2.unl.edu		22	0	0	0	0

Local site osgmon, stash-caches							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	its-condor-xrootd1.syr.edu		2	0	0	0	0
UP	mwt2-stashcache.campuscluster.illinois.edu		0	0	0	2	0
UP	stashcache.grid.uchicago.edu		1	0	0	1	0
UP	xrd-cache-1.t2.ucsd.edu		2	0	0	0	0

Local site osgmon, stash-origins							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	hcc-stashcache-origin.unl.edu		23	1	0	0	0
UP	origin.ligo.caltech.edu		1	0	0	0	0
UP	stash.osgconnect.net		1	0	0	0	0
UP	stashcache.fnal.gov		1	0	0	0	0

Local site osgmon, stash-redirectors							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	hcc-osg-redirector1.unl.edu		20	0	0	0	0
UP	hcc-osg-redirector2.unl.edu		26	0	0	0	0
UP	redirector.osgstorage.org		2	0	0	0	0

Local site osgmon, topology							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	hcc-osg-topology2.unl.edu		24	0	0	0	0
UP	hcc-osg-topology.unl.edu		22	0	0	0	0

Local site osgmon, xrootd							
state	Host	Icons	OK	Wa	Un	Cr	Pd
UP	xd-login.opensciencegrid.org		39	0	0	0	0
UP	xrootd-itb.unl.edu		28	0	0	0	0
UP	xrootd-local.unl.edu		28	0	0	0	0
UP	xrootd-mon.unl.edu		22	0	0	0	0
UP	xrootd.unl.edu		26	2	0	0	0



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# ***#4: Focus on Users***





# User-Centered Design & Development

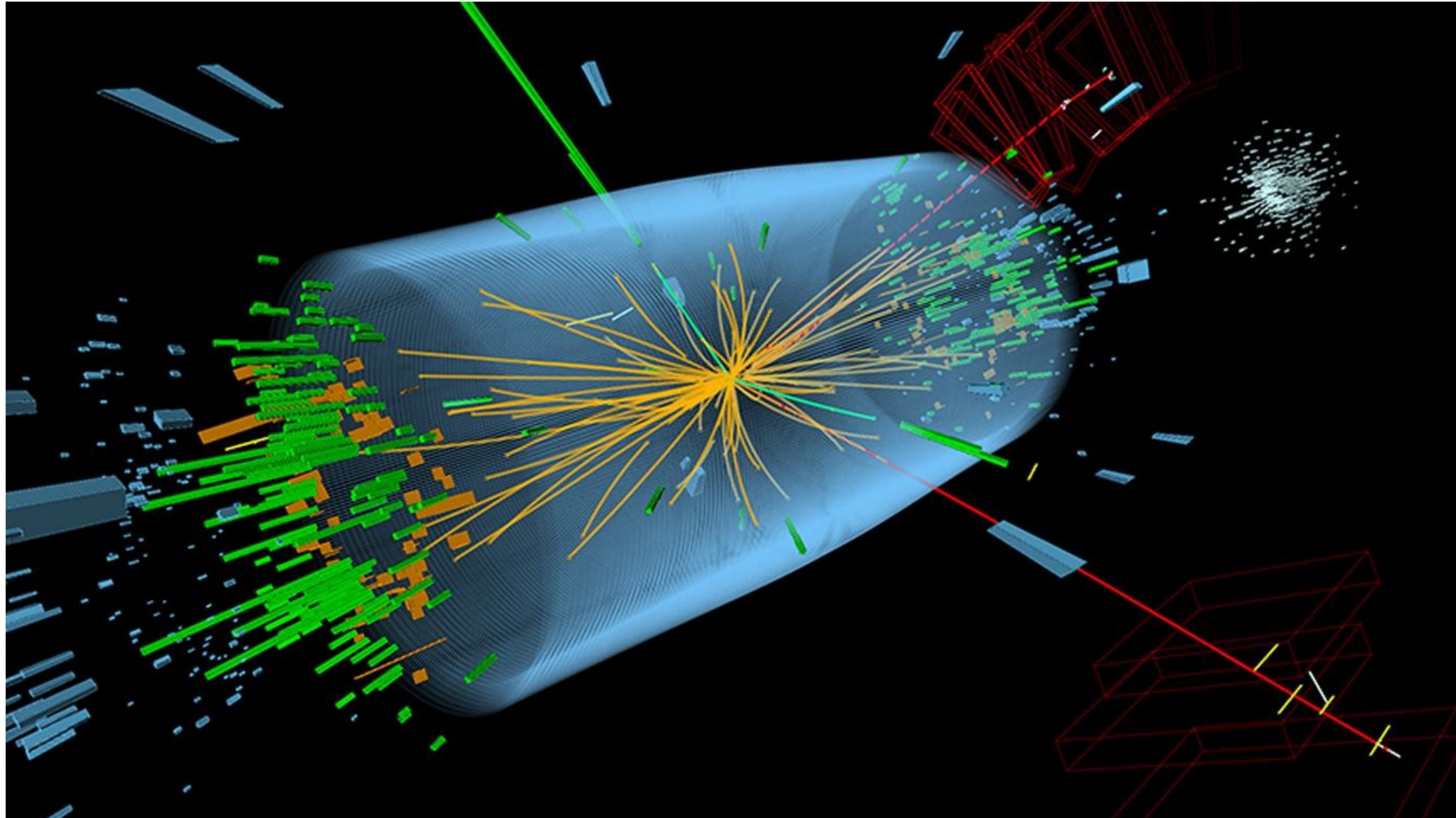
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- HTCondor has been driven by what users (you!) need and expect, balanced with core principles
- In contrast with “If you build it, they will come.”
- Example: Edgar Spalding – his early work pushed our abilities to handle large input files (images)





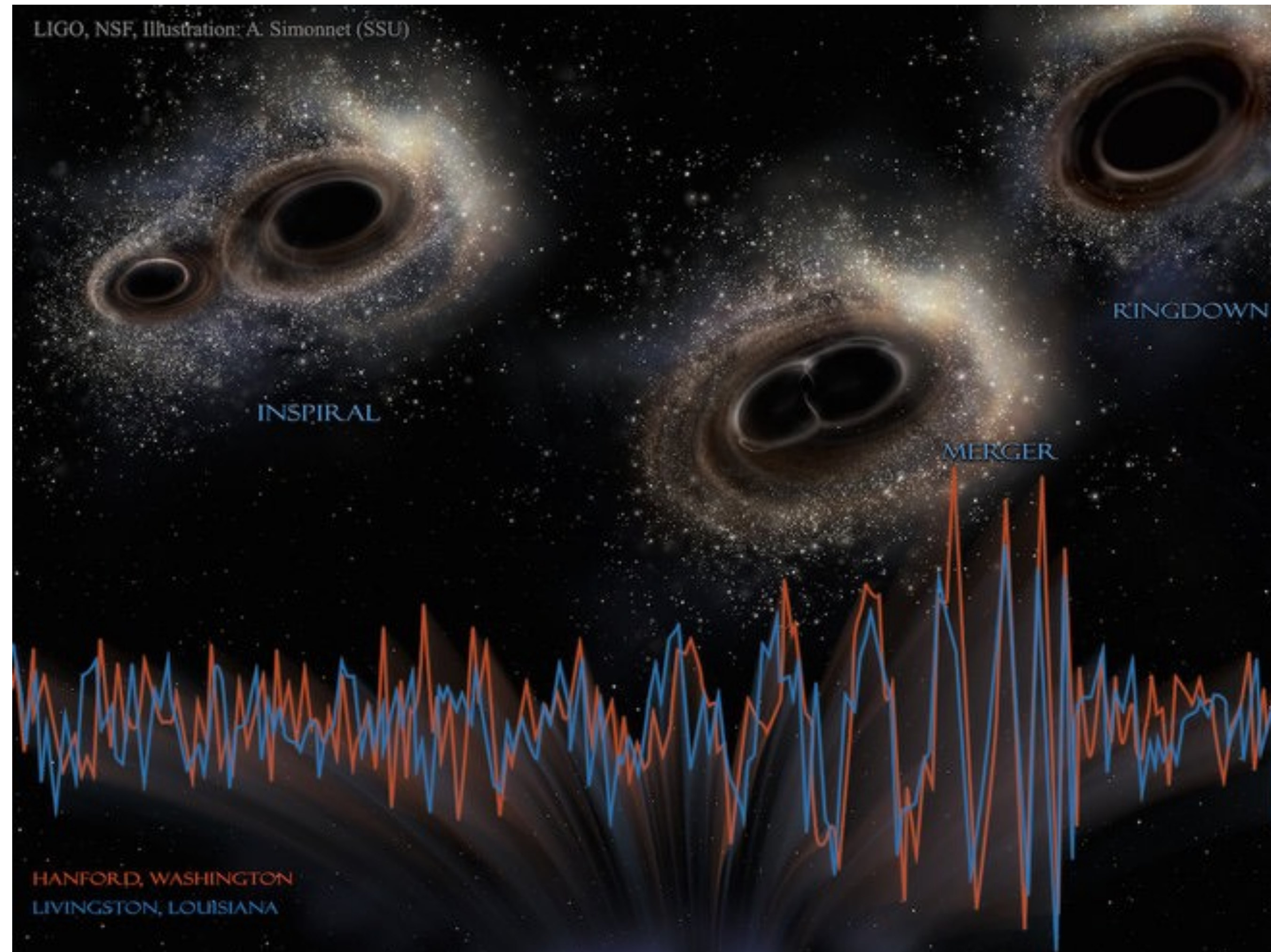
# Large Hadron Collider







# IGWN (LIGO-Virgo-Kagra)

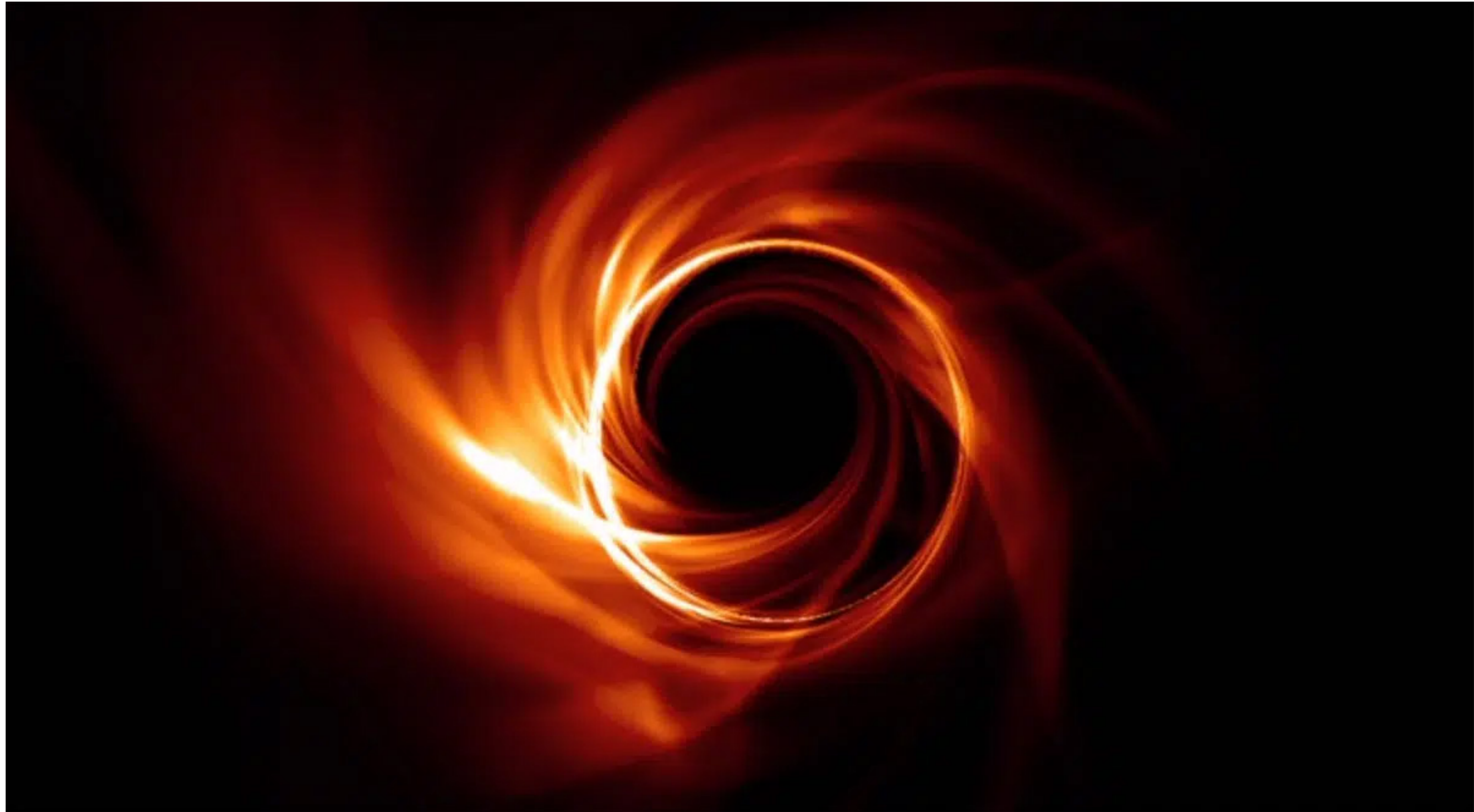






# Event Horizon Telescope

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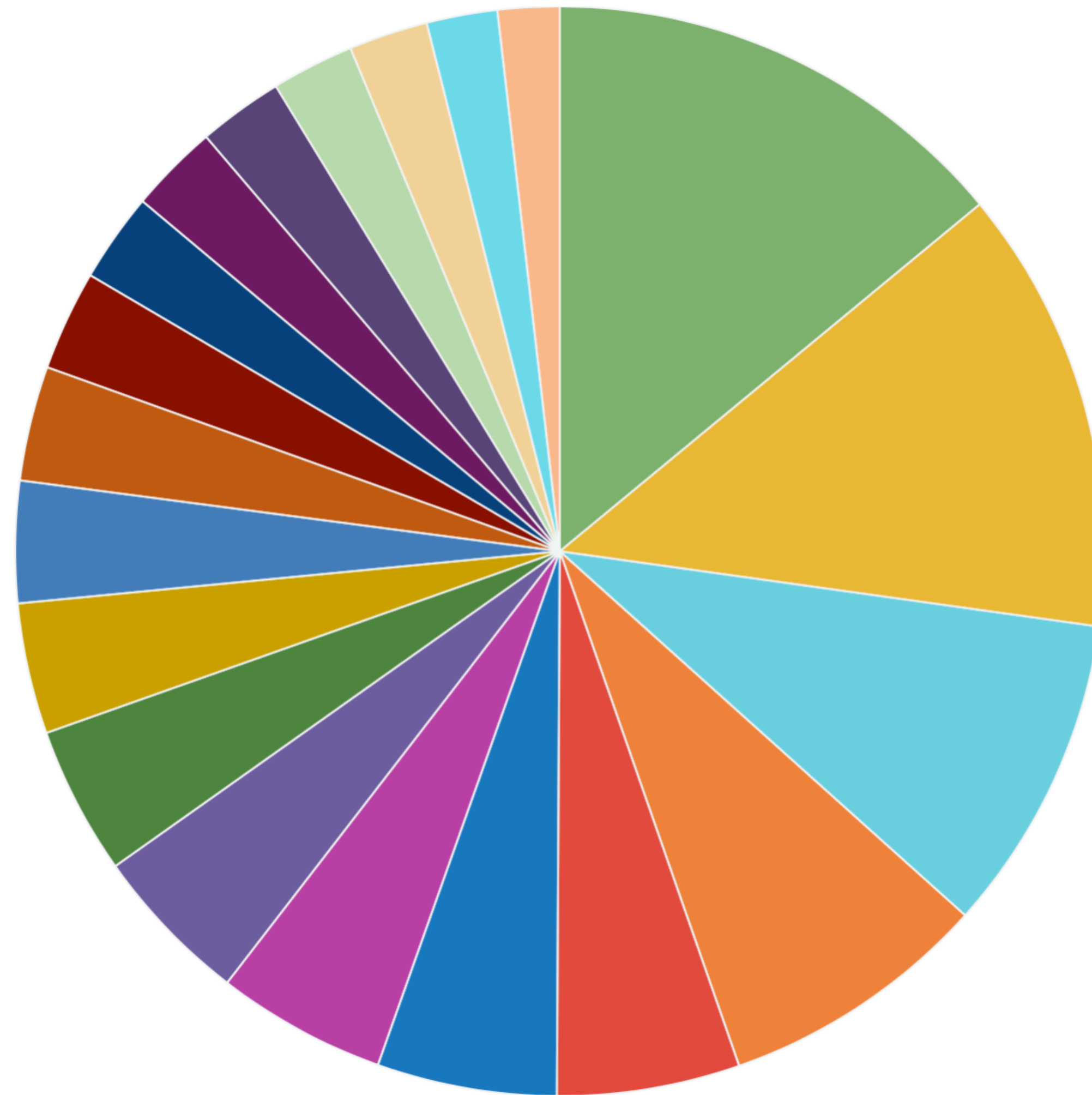


Source: EHT Theory Working Group, CK Chan





# Computing for All of Science



	total
WSU_3DHydro	19 Mil
Hawaii_Doetinchem	18 Mil
spt.all	13 Mil
TG-CHE200122	11 Mil
MSU_Berz	7 Mil
eht	7 Mil
EvolSims	7 Mil
Michigan_Riles	6 Mil
REDTOP	6 Mil
UChicago_Jonas	5 Mil
PixleyLab	5 Mil
microphases	5 Mil
BiomedInfo	4 Mil
MIT_Choi	4 Mil
Tufts_Hempstead	4 Mil
SSGAforCSP	3 Mil
CompBinFormMod	3 Mil
EIC	3 Mil
UCBerkeley_Altman	3 Mil
SC_Gothe	2 Mil





# Who Is Next?







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# ***#5: Teach To Fish***



# Teach To Fish

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Give a person a fish and  
you feed them for a day.

**Teach a person to fish and  
you feed them for a lifetime.**



# What Does “Teach to Fish” Mean for Us?

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- **Spurs innovation**
  - Researchers who understand their own computing tools can see ways to innovate and make discoveries
  - For example, our Showcase speakers!
- **Multiplies effort**
  - By teaching researchers (*you!*) to solve computing challenges, we can help many people with few staff
  - And if you teach *others* (in your lab, etc.), our effort becomes exponentially powerful



# Some Statistics on OSG Facilitation

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- **375** new OSG Connect accounts in past year (each with initial consultation, at least)
- **80** tickets (support, ) in past quarter
- **26** institutions engaged in past quarter
- **20** visits to office hours in past quarter
- All with just **2.5 FTEs** over five people!



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# ... And The Beginning



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# *Getting Resources*





# Free Resources – In Your Lab

## Server or cluster in your lab

- 👍 Not your laptop, control everything
- 👎 Buy and maintain it, not a lot of resources



[https://images.abmx.com/30/3004/abmx\\_3004\\_1\\_1200.jpg](https://images.abmx.com/30/3004/abmx_3004_1_1200.jpg)



# Free Resources – Local Cluster

## Department or campus cluster

- 👍 No/low direct costs, local help
- 👎 Shared; maybe Slurm, PBS/Torque, LSF...

No campus cluster? Talk to CIO!

**Note!** NSF CC\* Compute awards

<https://www.nsf.gov/pubs/2021/nsf21528/nsf21528.htm>



<https://www.pngall.com/wp-content/uploads/5/Server-Rack-PNG-Free-Image.png>





# Free Resources – Collaborators

## Collaborators

- 👍 No/low direct costs, may be tailored to project
- 👎 Shared, project-specific, hard to come by



<https://www.dunescience.org/about-the-collaboration/>

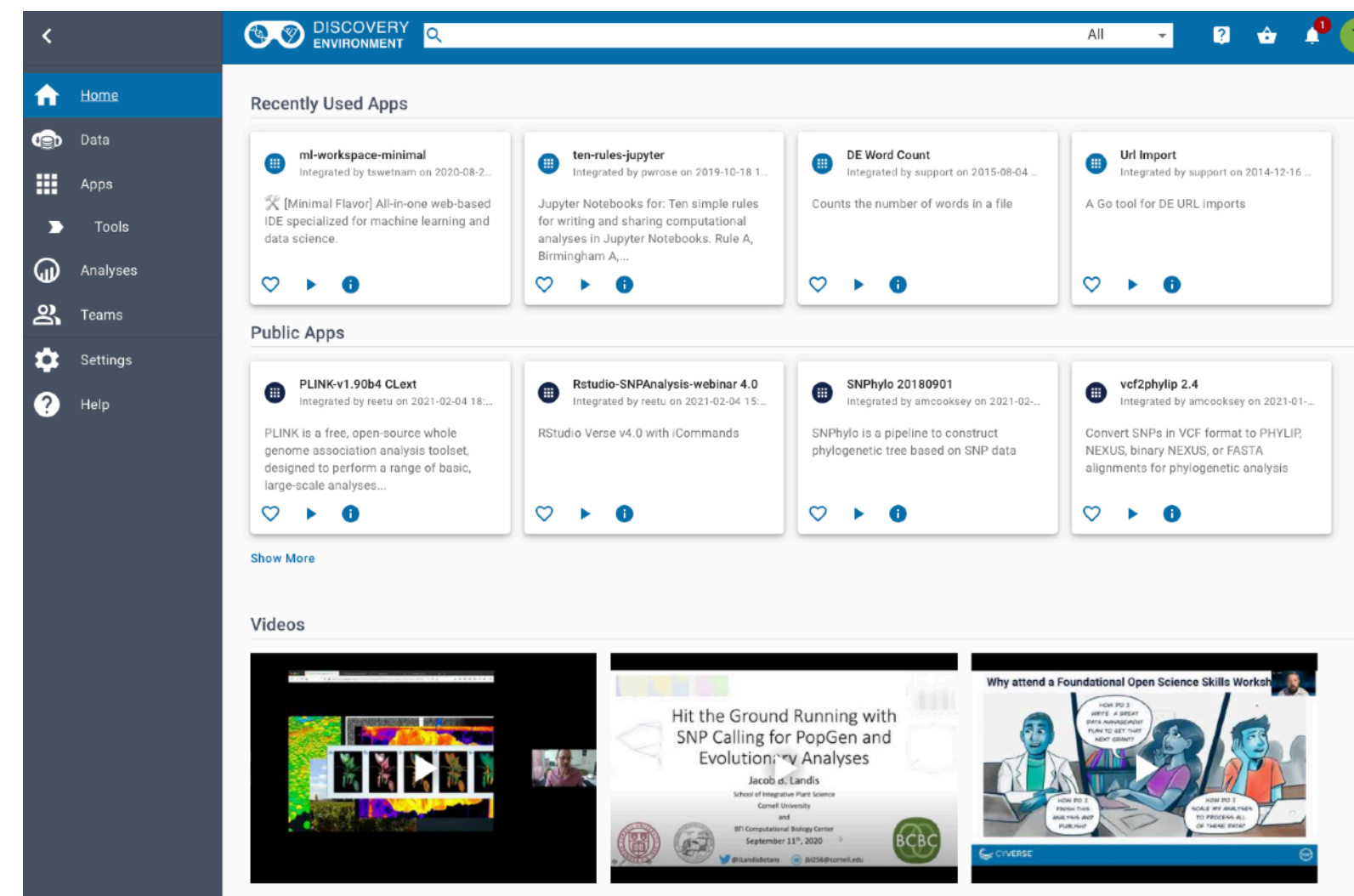




# Free Resources – Science Gateways

Science Gateways (e.g., web front-end to a cluster)

- 👍 Easy to use, no/low cost
- 👎 Only for pre-defined use cases







# Commercial Resources

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- **Commercial clouds** (*Amazon, Google, Microsoft, ...*)
  - 👍 Don't own, high availability, many options (e.g., GPUs), ...
  - 👎 Pay/hour, data out may be costly; challenging to manage
- **Managed clouds** (*Azure CycleCloud, Globus Genomics, ...*)
  - 👍 As above, but *less* to manage
  - 👎 Costs more (paying someone to manage), fewer options?
- But keep commercial options in mind:
  - Credits may be available
  - May be able to write into grants
  - May be helpful for burst of activity (e.g., for a deadline)



# PATH Facility

The **PATH Facility** is a purpose-built, national-scale dHTC resource meant to deliver computational capacity to **NSF** researchers



- New in 2022!
- Can apply for credits – existing or new NSF award
- Credits go toward dedicated dHTC resources
- See [PATH website](https://www.nsf.gov/pubs/2022/nsf22051/nsf22051.jsp) and NSF DCL 22-051 for more:  
<https://www.nsf.gov/pubs/2022/nsf22051/nsf22051.jsp>



# Your School Accounts

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- **learn.chtc.wisc.edu** – may keep for ~1 year
  - We will warn you before removing account
- **OSG Connect** account
  - If just created for School, temporary (~1 month)
  - But, just take easy steps to convert to full account
  - See School website:  
<https://osg-htc.org/user-school-2022/logistics/projects/>
- Remember that Access Points are not backed up!



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# *Staying in Touch*





# How to Reach Us

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- **For OSG Connect, Connect Client, OSG sites...**
  - [user-support@opensciencegrid.org](mailto:user-support@opensciencegrid.org)
  - Reaches the OSG Research Computing Facilitators
- **For learn, CHTC, and anything else**
  - [user-school@opensciencegrid.org](mailto:user-school@opensciencegrid.org)
  - Reaches Tim and Christina... and indirectly, many others
- **Any time, for any reason, email us directly:**
  - Tim Cartwright <[cat@cs.wisc.edu](mailto:cat@cs.wisc.edu)>
  - Christina Koch <[ckoch5@wisc.edu](mailto:ckoch5@wisc.edu)>



# Online Support

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## Websites

[htcondor.org](http://htcondor.org)

[htcondor.org/manual](http://htcondor.org/manual)

[www.opensciencegrid.org](http://www.opensciencegrid.org)

[support.opensciencegrid.org](http://support.opensciencegrid.org)

[osgconnect.net](http://osgconnect.net)

[chtc.cs.wisc.edu](http://chtc.cs.wisc.edu)

[chtc.cs.wisc.edu/guides](http://chtc.cs.wisc.edu/guides)

HTCondor homepage

HTCondor manual

OSG homepage

Forums, docs, support

OSG Connect

CHTC Website

CHTC How-To Guides

## Mailing Lists

[user-school@opensciencegrid.org](mailto:user-school@opensciencegrid.org)

[help@opensciencegrid.org](mailto:help@opensciencegrid.org)

will remain

general OSG help



# Meetings

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- **OSG All-Hands Meeting**
  - Traditionally in March, likely moving for 2023
  - David Swanson Award => former School participant
- **HTCondor Week**
- **European HTCondor Workshop**



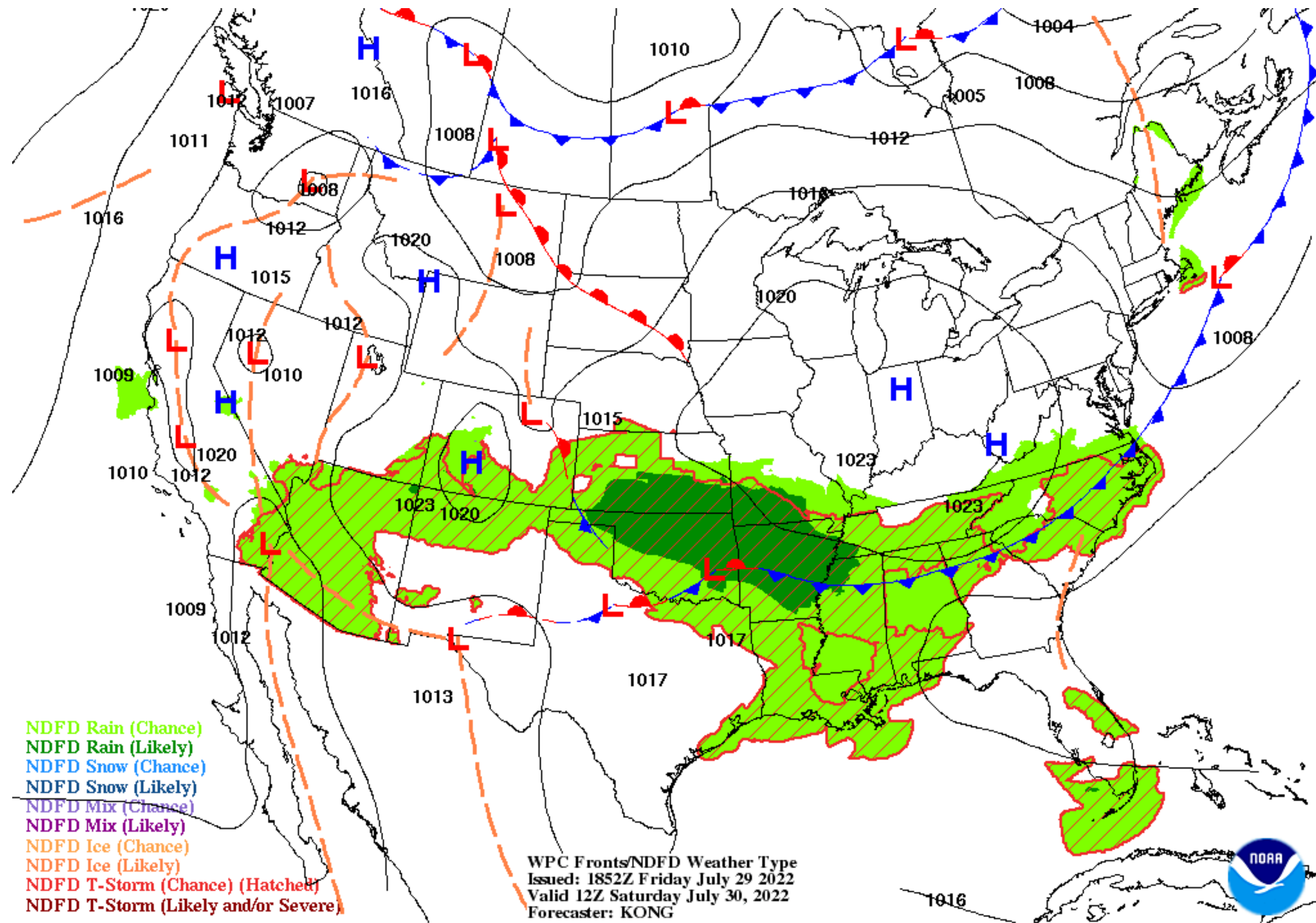


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# *Final Logistics*



# Saturday Morning





# Travel

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- Transportation emails went out today
  - Most people will take taxi/rideshare
  - Payer should write down who shared the ride
- Remember the travel advice page:  
<https://osg-htc.org/user-school-2022/logistics/travel-advice/>
- If you encounter issues:
  - Try the airline first
  - Call Travel Inc. if necessary (we are charged \$18)
  - Let us know (if you want to and have time)





# Reimbursements

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- What can be reimbursed?
  - Bus fare to/from Madison (if you paid)
  - Taxi or rideshare to/from Madison airport
  - Driving mileage, *if prearranged*
  - Dinners (Sunday – Thursday), up to \$30 each
  - Other *prearranged* things
  - It is best to have actual receipts
- How to get reimbursed?  
<https://osg-htc.org/user-school-2022/logistics/reimbursements/>



# Short Essay (If No Lightning Talk)

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- Similar to the lightning talks, but written
  - Basic summary of current research work
  - One key computational challenge
  - How will you apply new knowledge & skills to research?
- Due by the end of August
- Submit to School mailing list for review



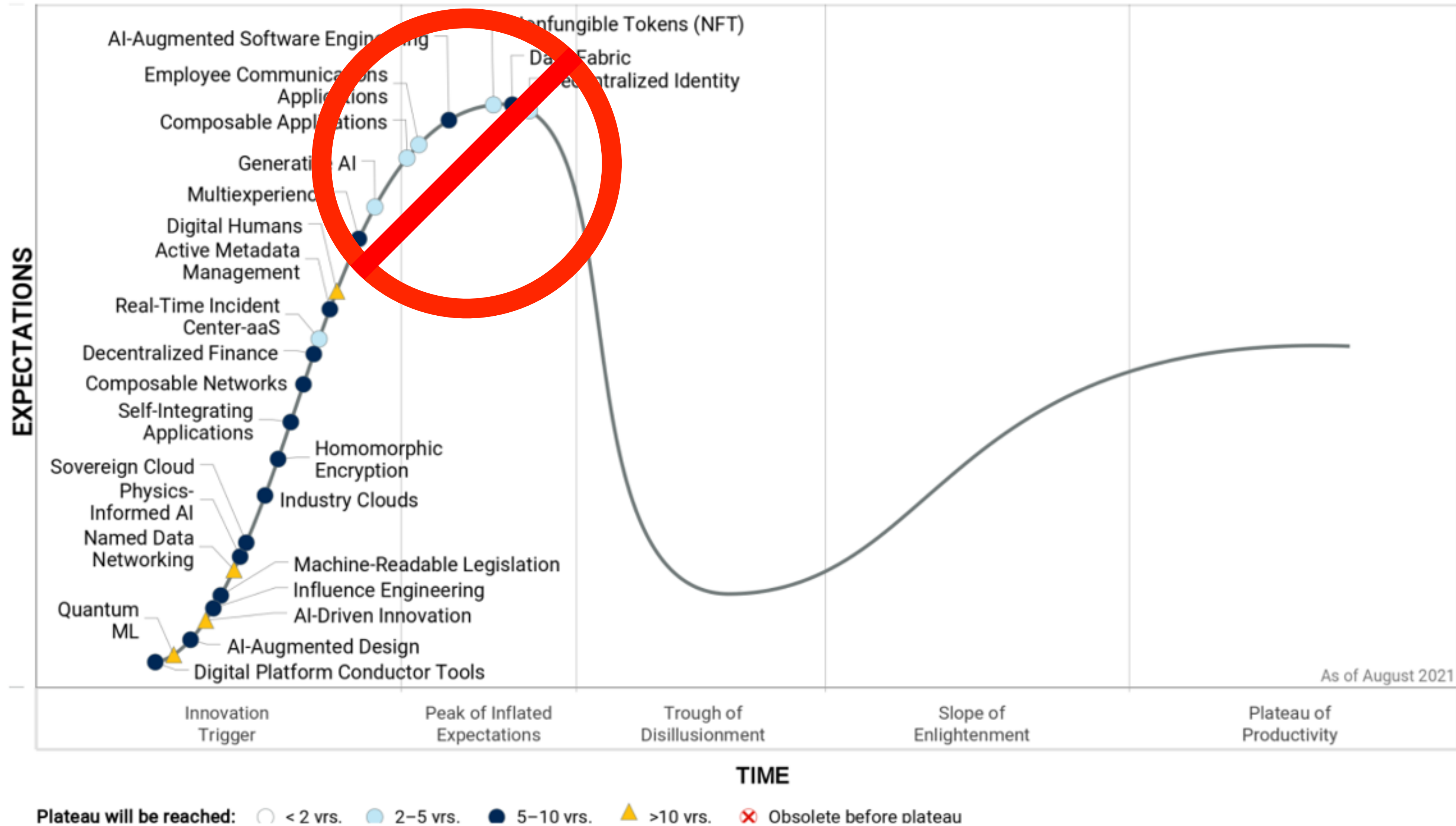
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# Forward





# Temper Hype With Principles





# How to Work With Us

- We are driven by user needs and expectations, plus our principles
- So push us to help make your research possible
- And we may push on you to take your work even further!







# Be Part of the Community







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**Don't let computing be  
a barrier to your science!**



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**THANK YOU!**



# Closing Dinner

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**Union South, Industry Room and outside  
(3rd floor)**

**6:30 p.m.**





# Acknowledgements

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This work was supported by NSF grants  
MPS-1148698, OAC-1836650, and OAC-2030508