The Principles of HTC

OSG User School 2019 – Friday afternoon

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OSG User School Director
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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

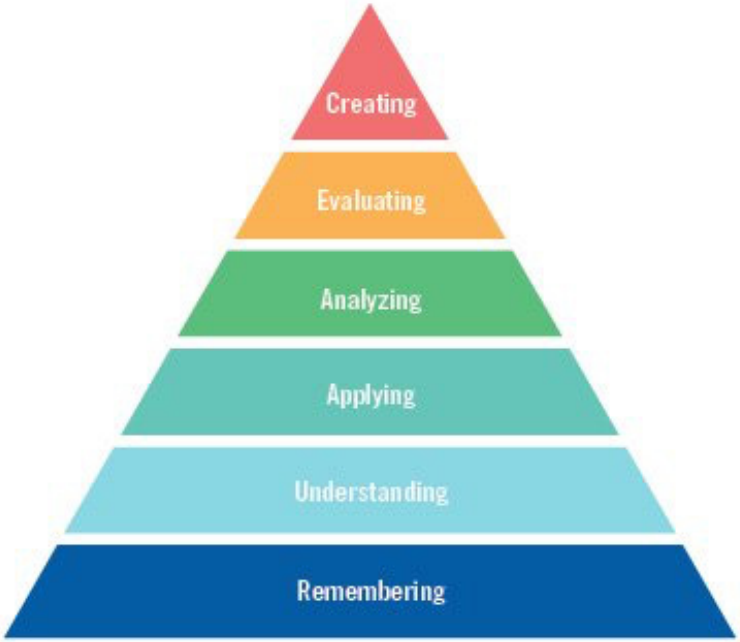
Miron Livny

- Founder and leader of Condor Project since mid-1980s
- Now leads the Center for High Throughput Computing (CHTC)
- PI and Technical Director of OSG
- Coined term “high throughput computing”
- Has principled approach to HTC

Why?

Why Now?

- People ask why this talk comes at the end
- 4 days ago, most of you knew little about HTC
- Then you were ***engaged in doing*** HTC for days
- ***Now*** you are ready to think abstractly about it



Why Talk About Principles?

What has been
is what will be,
and what has been done
is what will be done,
and ***there is nothing new under the sun***.

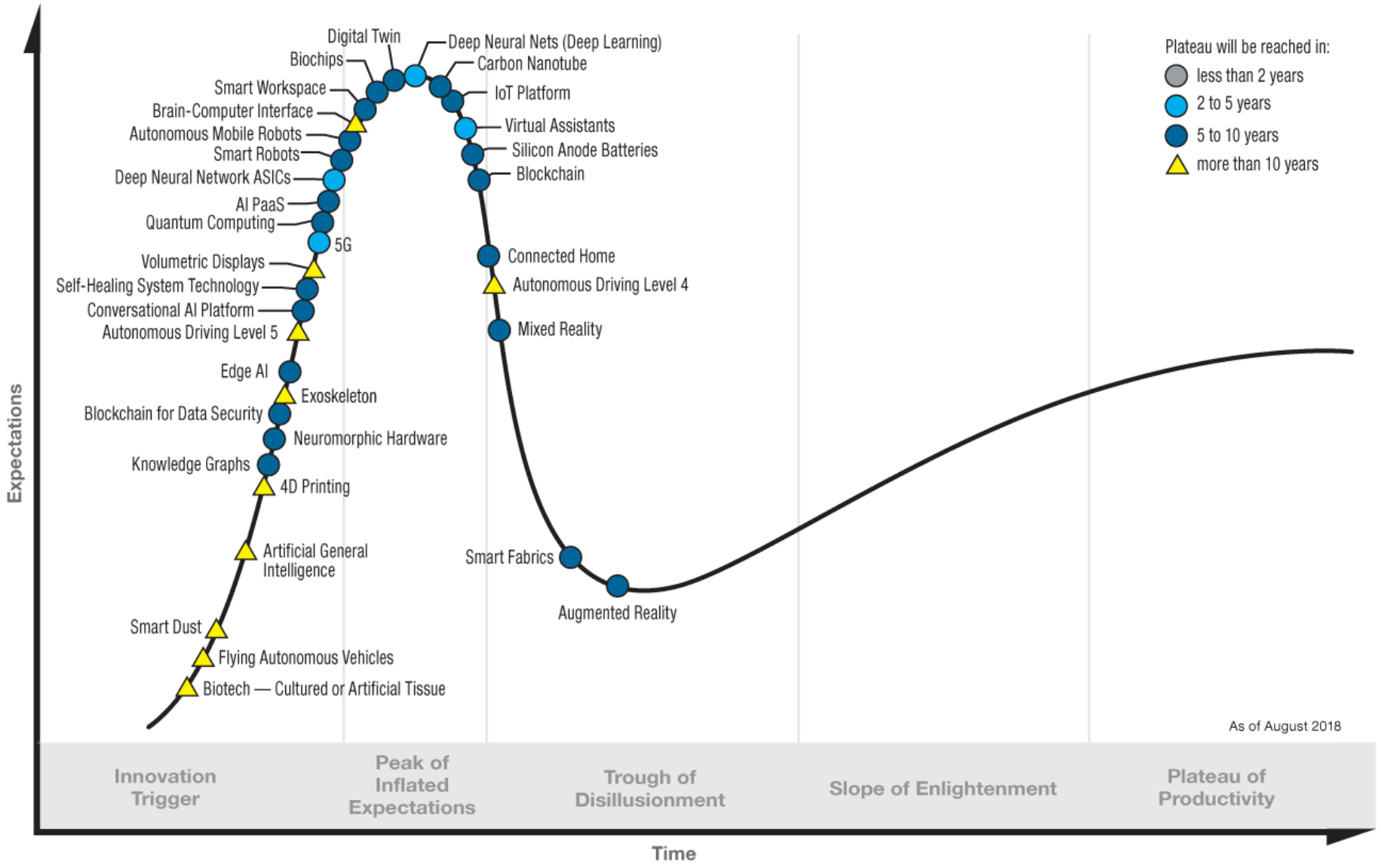
— Ecclesiastes 1:9 (ESV)

Attributed to Koheleth, who was Ecclesiastes or its author, often taken to be Solomon, son of David, king in Jerusalem, ~950 BCE

Ecclesiastes, (קֹהֶלֶת, Koheleth, "son of David, and king in Jerusalem," alias Solomon, wood engraving, Gustave Doré (1832–1883)

Open Science Grid

Gartner Hype Cycle



Source: https://www.gartner.com/smarterwithgartner/5-trends-emerge-in-gartner-hype-cycle-for-emerging-technologies-2018/

Recent Paradigm Shifts

1970s Computing capacity packaged and sold in small units

2000s Computing capacity available to lease by the minute

aws Azure Google Cloud

BUT: Principles haven't changed with these shifts!

A Brief History

1983	Miron Livny completes Ph.D. th
1985	First Condor deployment
1992	Completed run of 250,000
1994	LHC approved
1996	Introduced "High Throughl
2000	Start of Trillium project (PP
2004	Start of EGEE (Enabling Grids
2005	Start of Open Science Grid
2009	LHC Run 1 begins
2010	*Perspectives on Grid Computing*
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
2019	34 years and still going strong…

I was doing Cloud computing way before people called it Grid computing.

– Attrib. to Miron Livny

Principles

Open Science Grid

What System Is This?

- ***Mystery System X***
  - Provides a ***lot*** of computing
  - Has high availability and reliability
  - Degrades gracefully
  - Spreads the workload automatically
  - Grows (and shrinks) easily when needed
  - Responds well to temporary overloads
  - Adapts easily to new uses

- HTCondor? OSG? Amazon EC2? Other Clouds?

Open Science Grid

Surprise!

- Those were all ***promised*** features!
- … of distributed data processing systems
- … from the 1970s!!!

  (Adapted from: Enslow, P. H., Jr. (1978). What is a "distributed" data processing system? *Computer, 11*(1), 13–21. doi:10.1109/C-M.1978.217901)

- Sound like promises of today: HTC, grid, cloud

Criteria for Distributed Computing

1. Multiplicity of resources
2. Component interconnection
3. Unity of control
4. System transparency
5. Component autonomy

Enslow, P. H., Jr., & Saponas, T. G. (1981). *Distributed and decentralized control in fully distributed processing systems: A survey of applicable models* (GIT-ICS-81/02). Georgia Institute of Technology.

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Principle #1

Unity of Control: All the components of the system should be **unified** in their desire to achieve a **common goal**. This goal will determine the rules according to which each of these elements will be controlled.

Principle #2

Component Autonomy: The components of the system… should be **autonomous** and are thus afforded the ability to refuse a request of service made by another element. However, in order to achieve the system's goals they have to interact in a **cooperative** manner and thus adhere to a common set of policies.

Unity vs. Autonomy

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!

Photo: Hayley Ringle, Phoenix Business Journal

Sharing Is Caring

Should I share my resource and, if I do, with whom and when?

Image: Patrick Herrera

HTC Is Sharing

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

— Miron Livny

Sharing Leads to Community

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

— Miron Livny

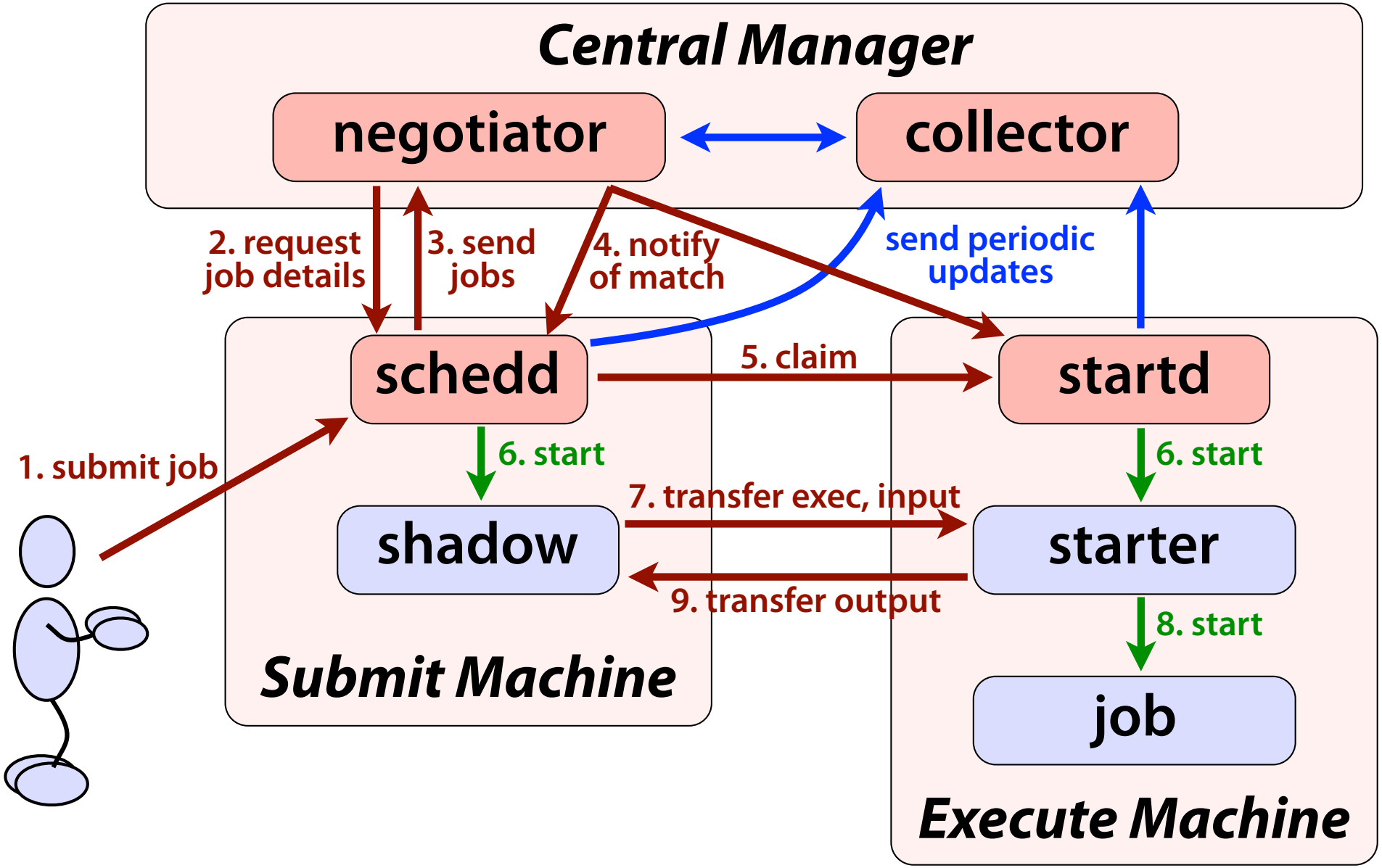
Principle #3

High Throughput Computing requires automation, as it is a 24-7-365 activity that scales well beyond human interaction

FLOPY ≠ FLOPS × (60×60×24×365)

1 job × 100 KHrs ≠ 100K jobs × 1 Hr

Resource Acquisition & Job Delegation



System Maintenance

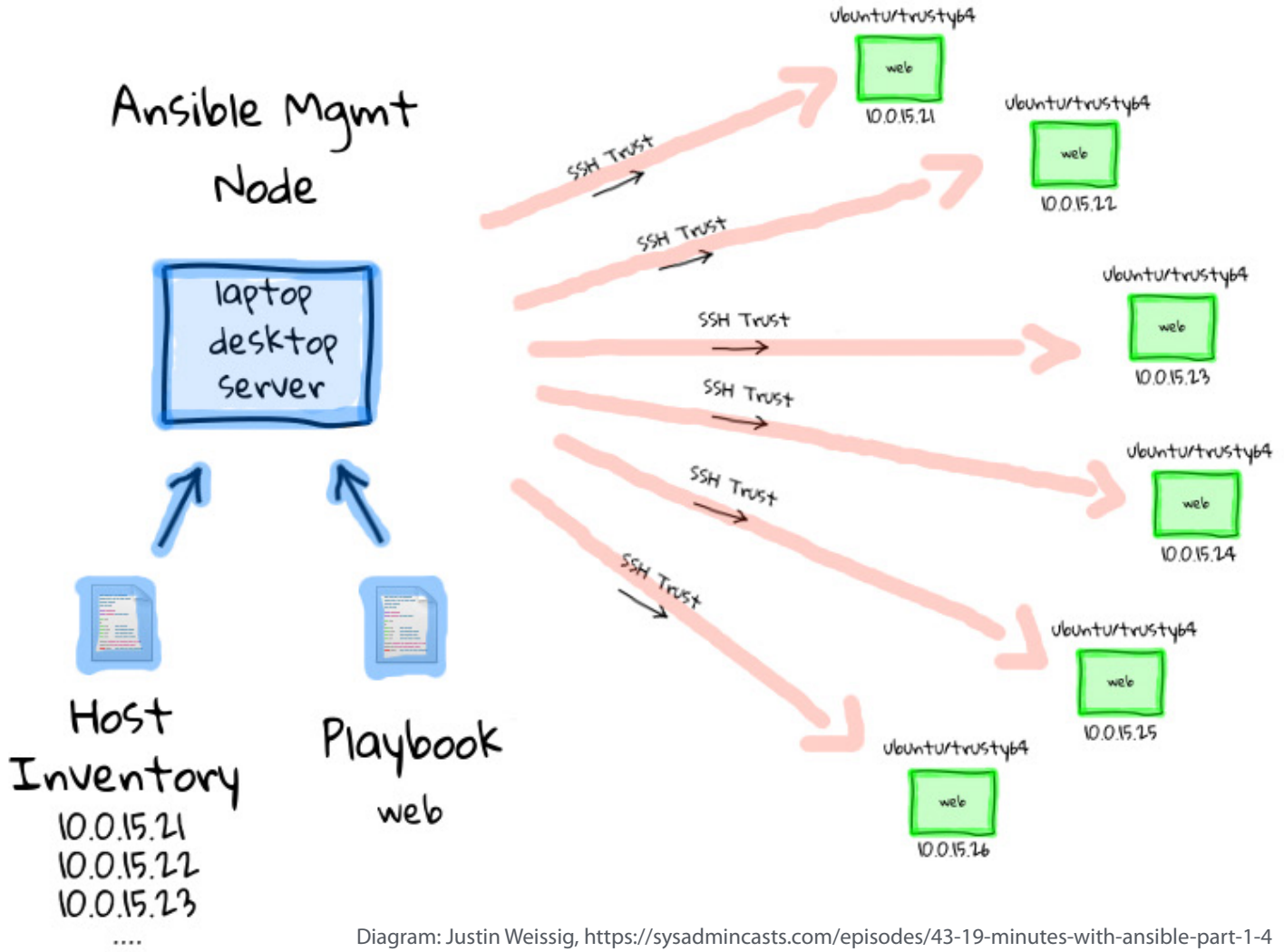
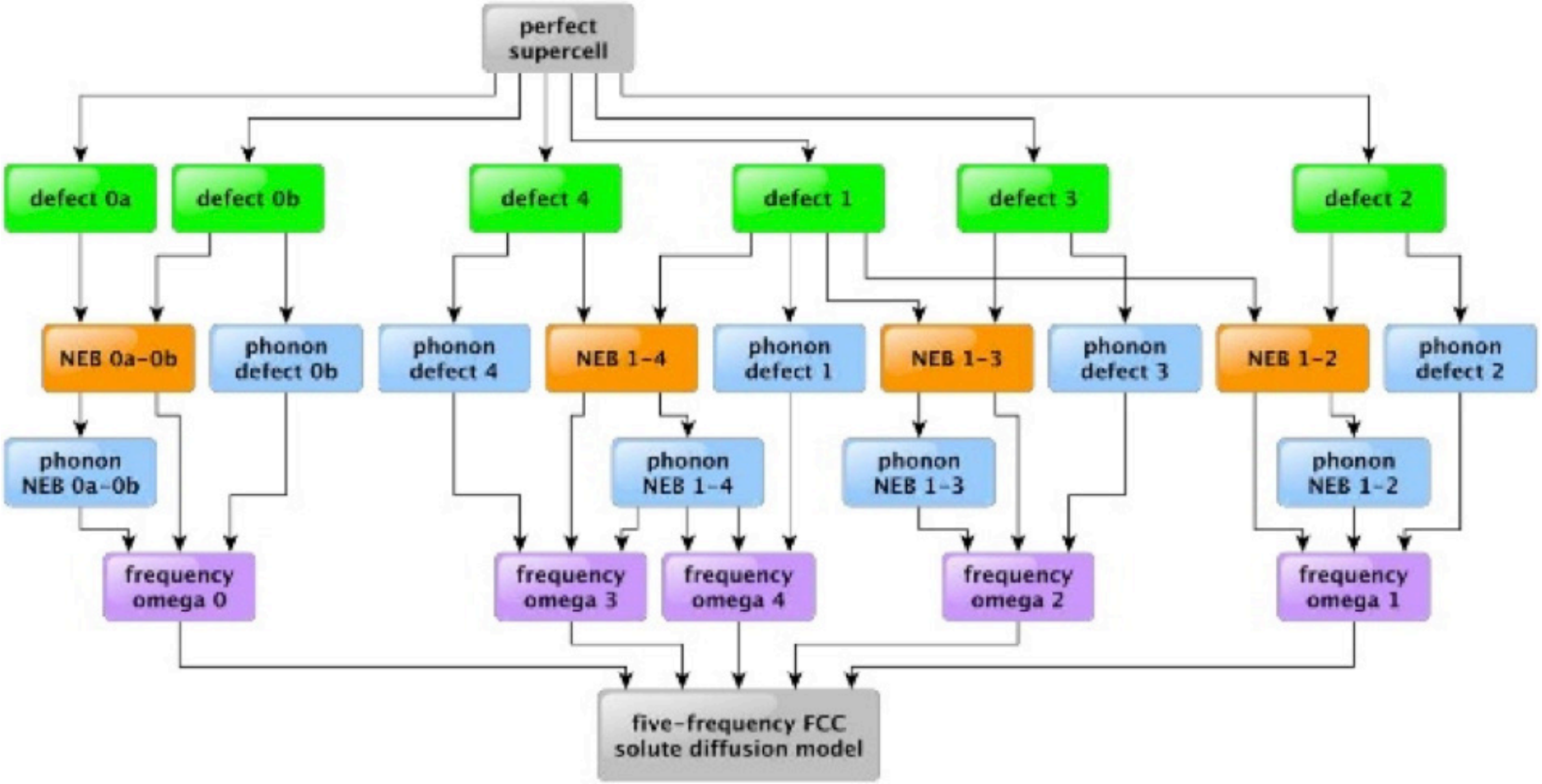


Diagram: Justin Weissig, https://sysadmincasts.com/episodes/43-19-minutes-with-ansible-part-1-4

Open Science Grid

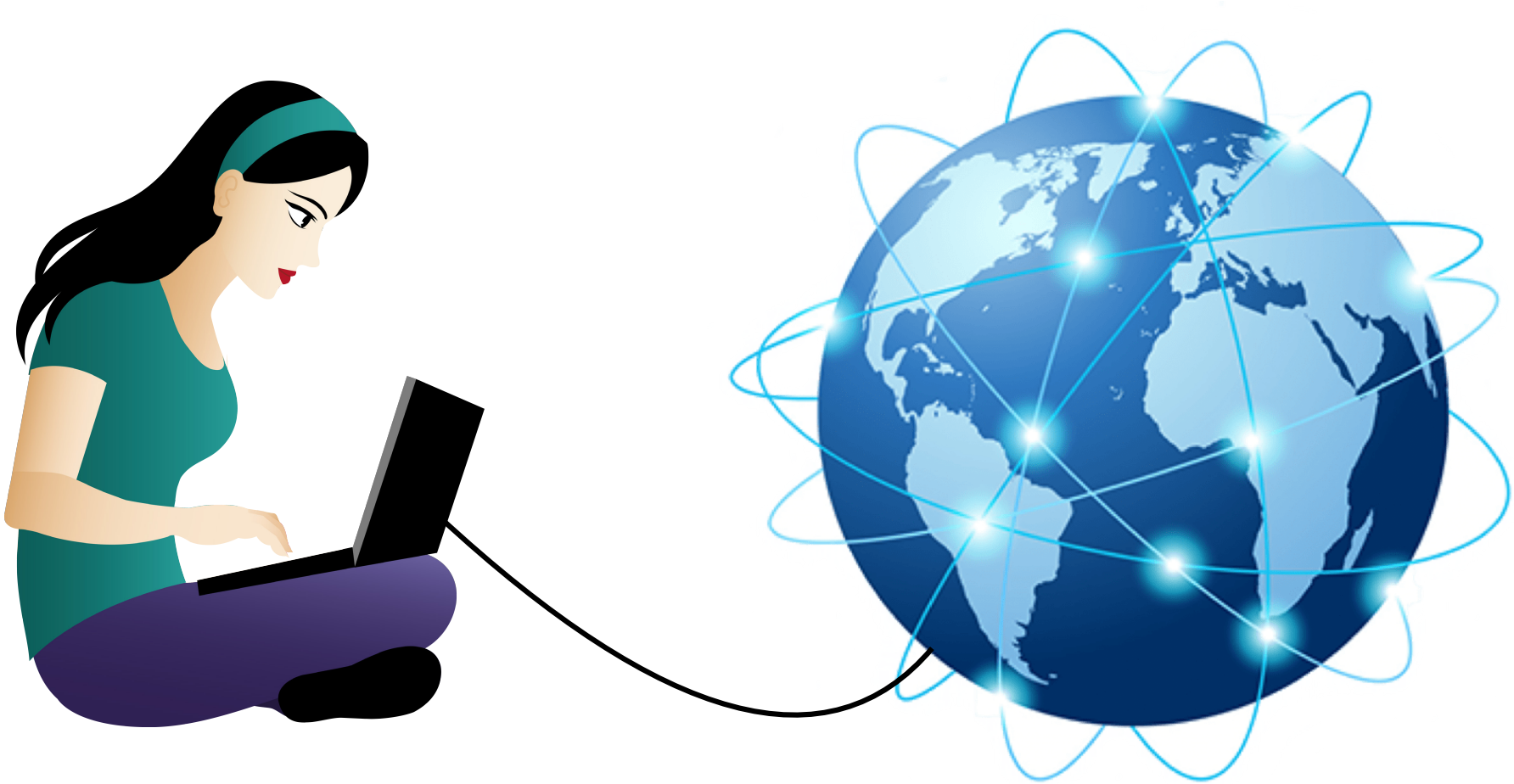
User Workflows



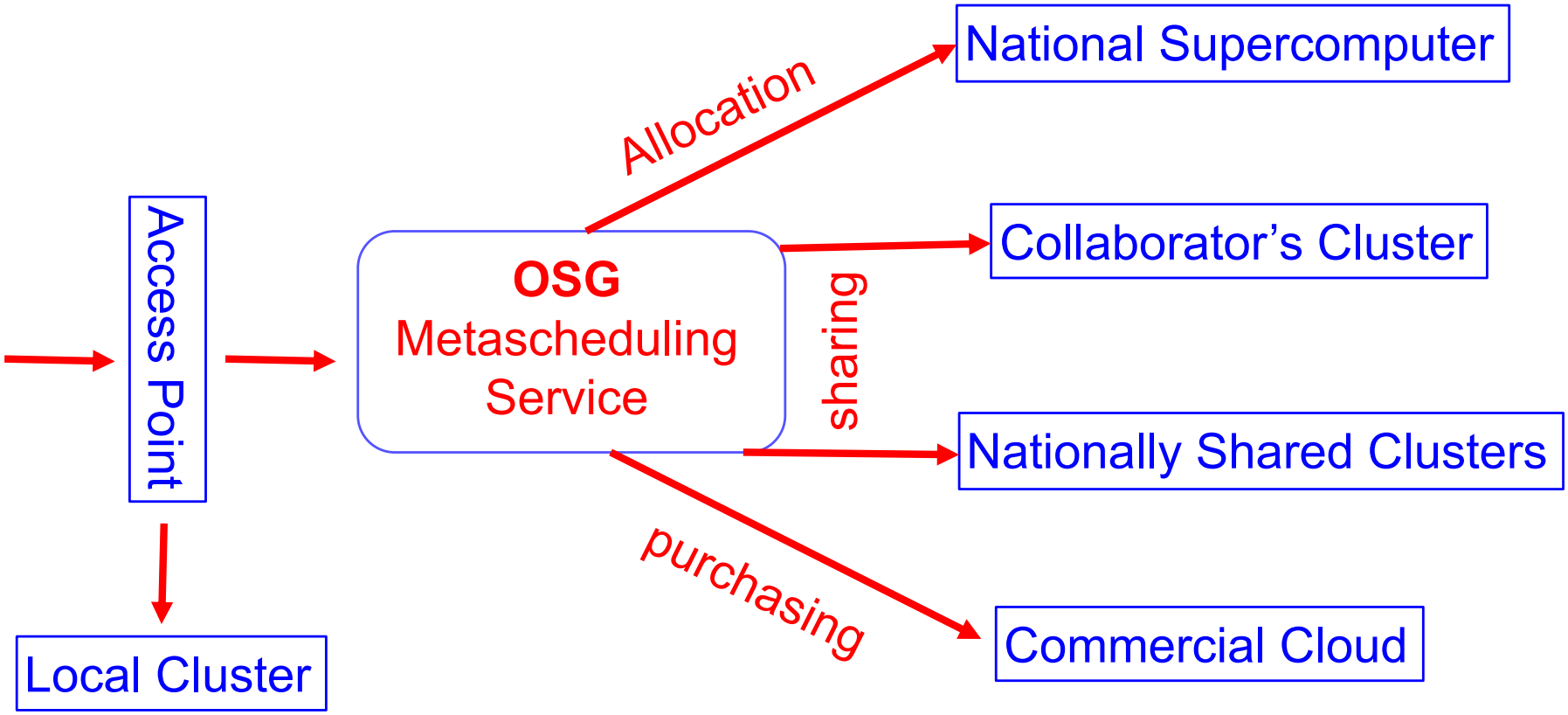
Source: Professor Dane Morgan, University of Wisconsin–Madison

Principle #4

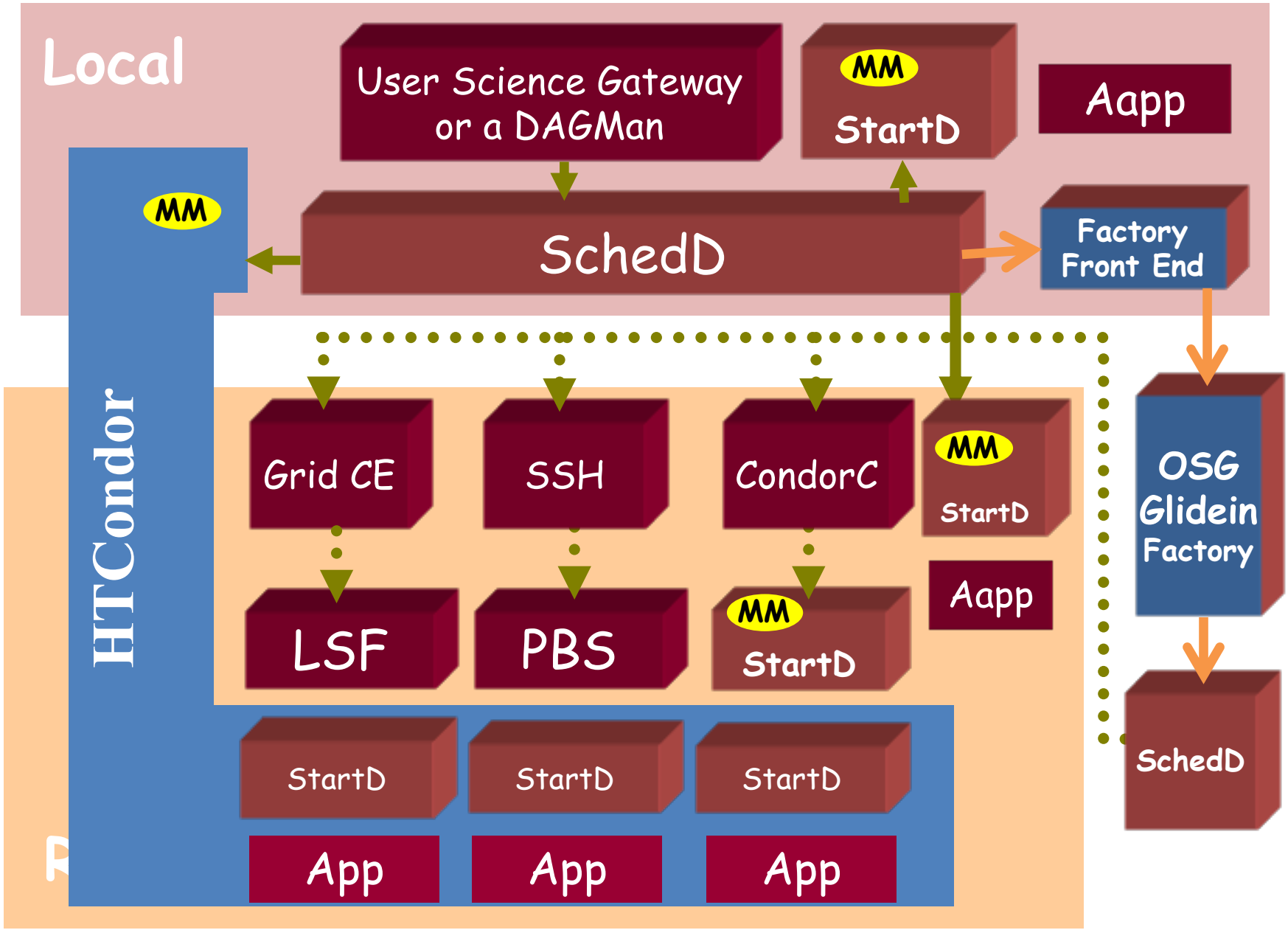
Submit locally, run globally



OSG Is Getting There…



… But It Is Still Complex …



Open Science Grid

… 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

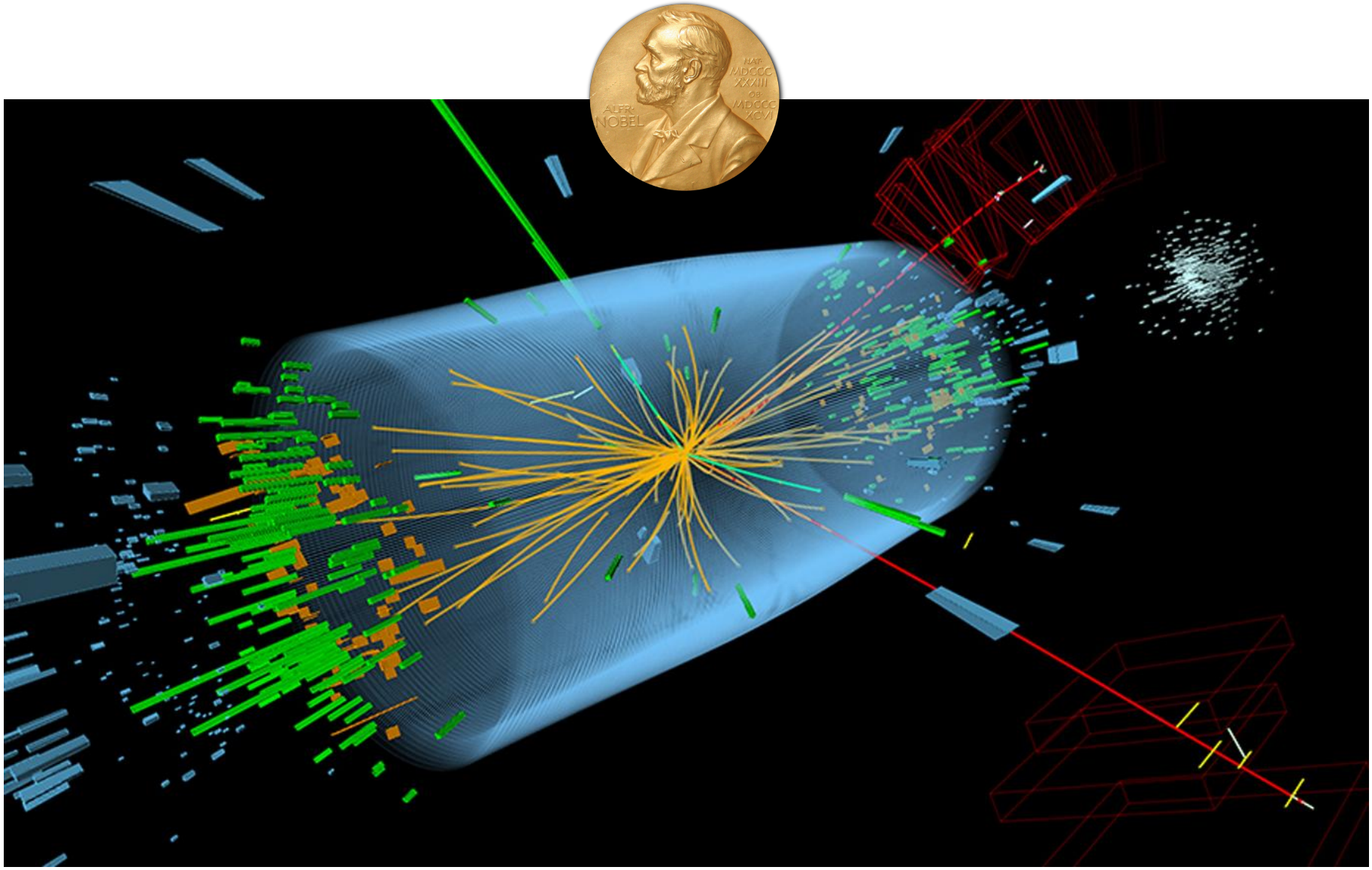
The Most Important Principle

Principle #5

Focus on the needs and expectations of researchers

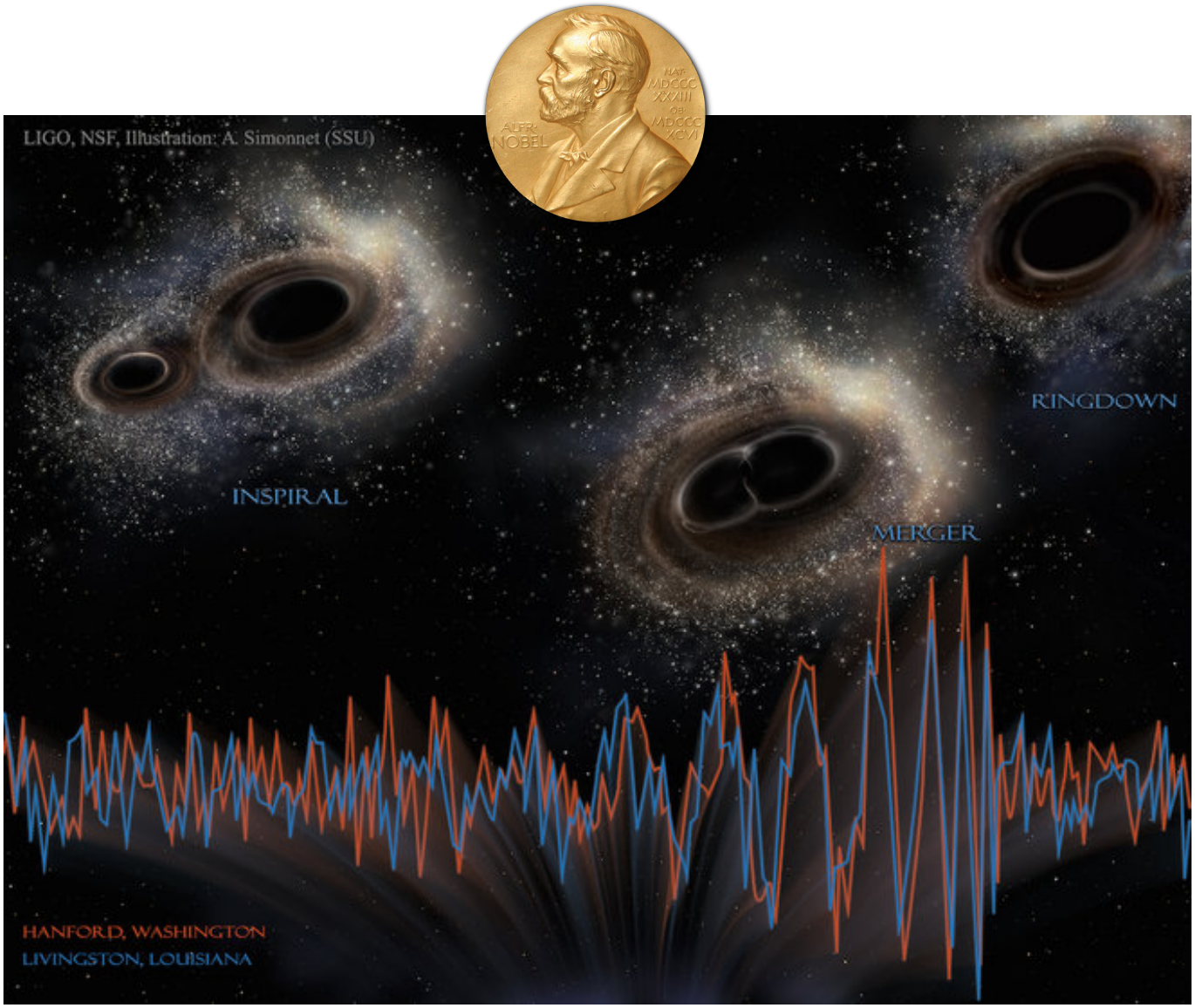
Open Science Grid

Large Hadron Collider

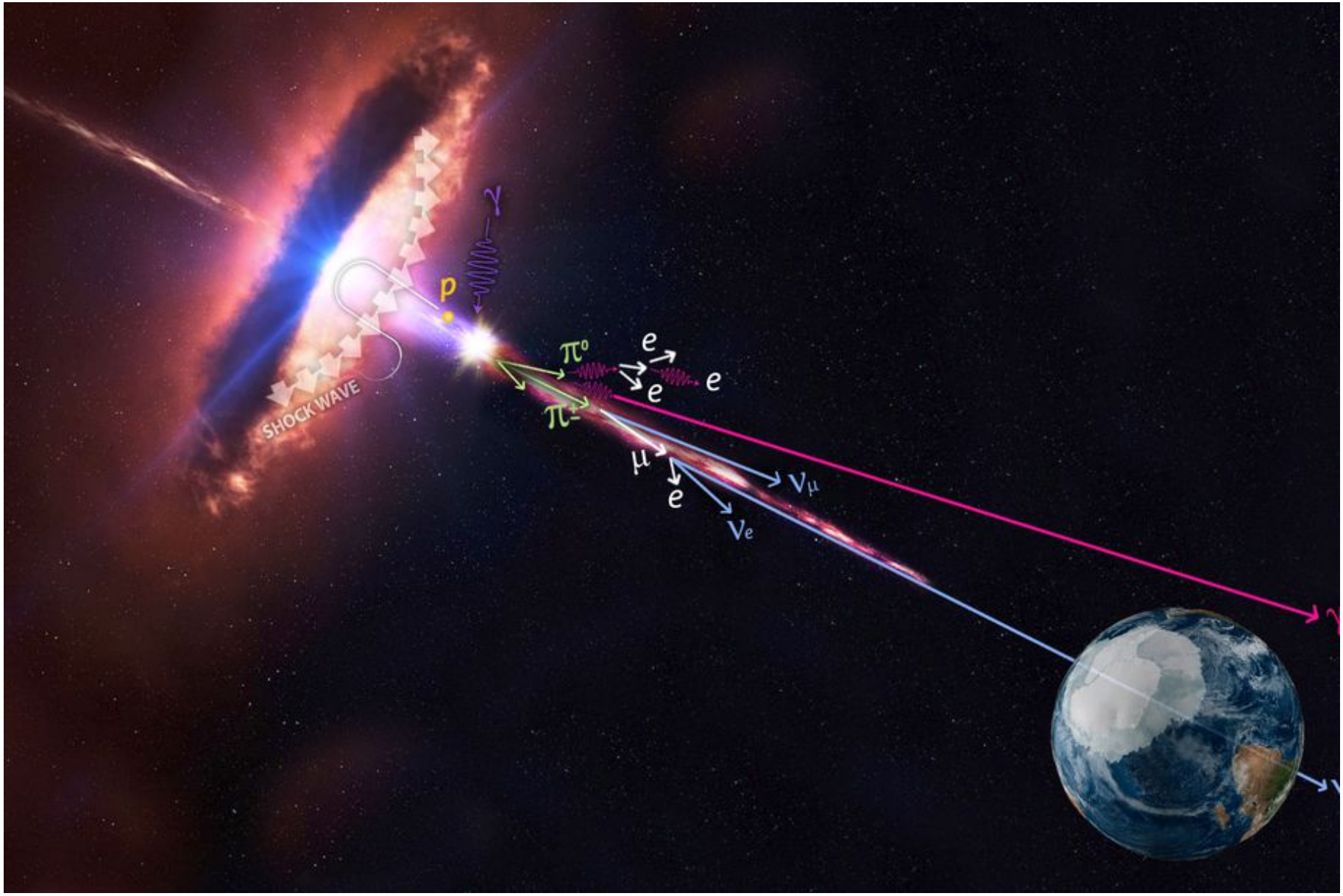


Source: University of Chicago

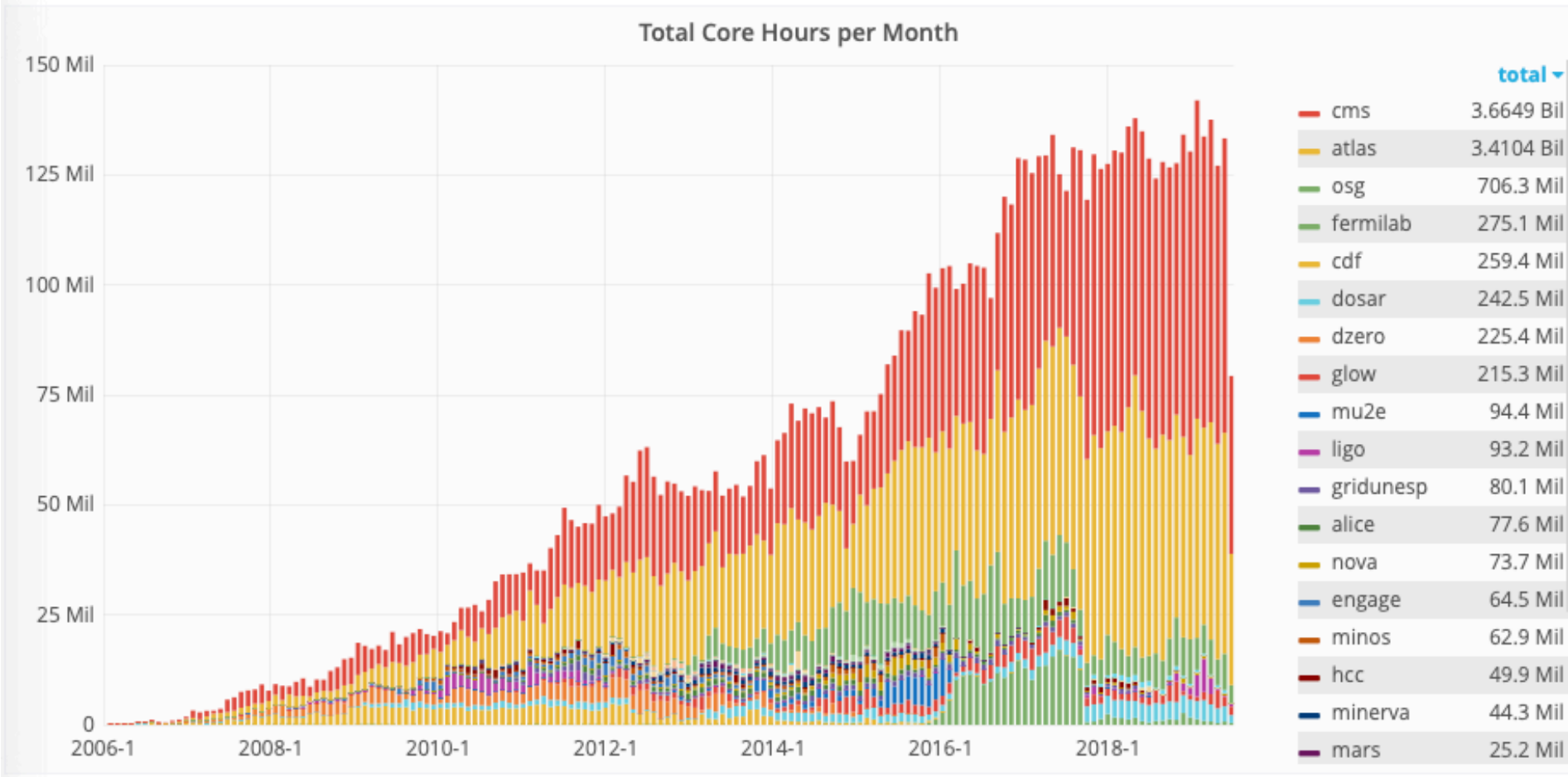
LIGO


LIGO, NSF, Illustration: A. Simonnet (SSU)
INSPIRAL
MERGER
RINGDOWN
HANFORD, WASHINGTON
LIVINGSTON, LOUISIANA

IceCube

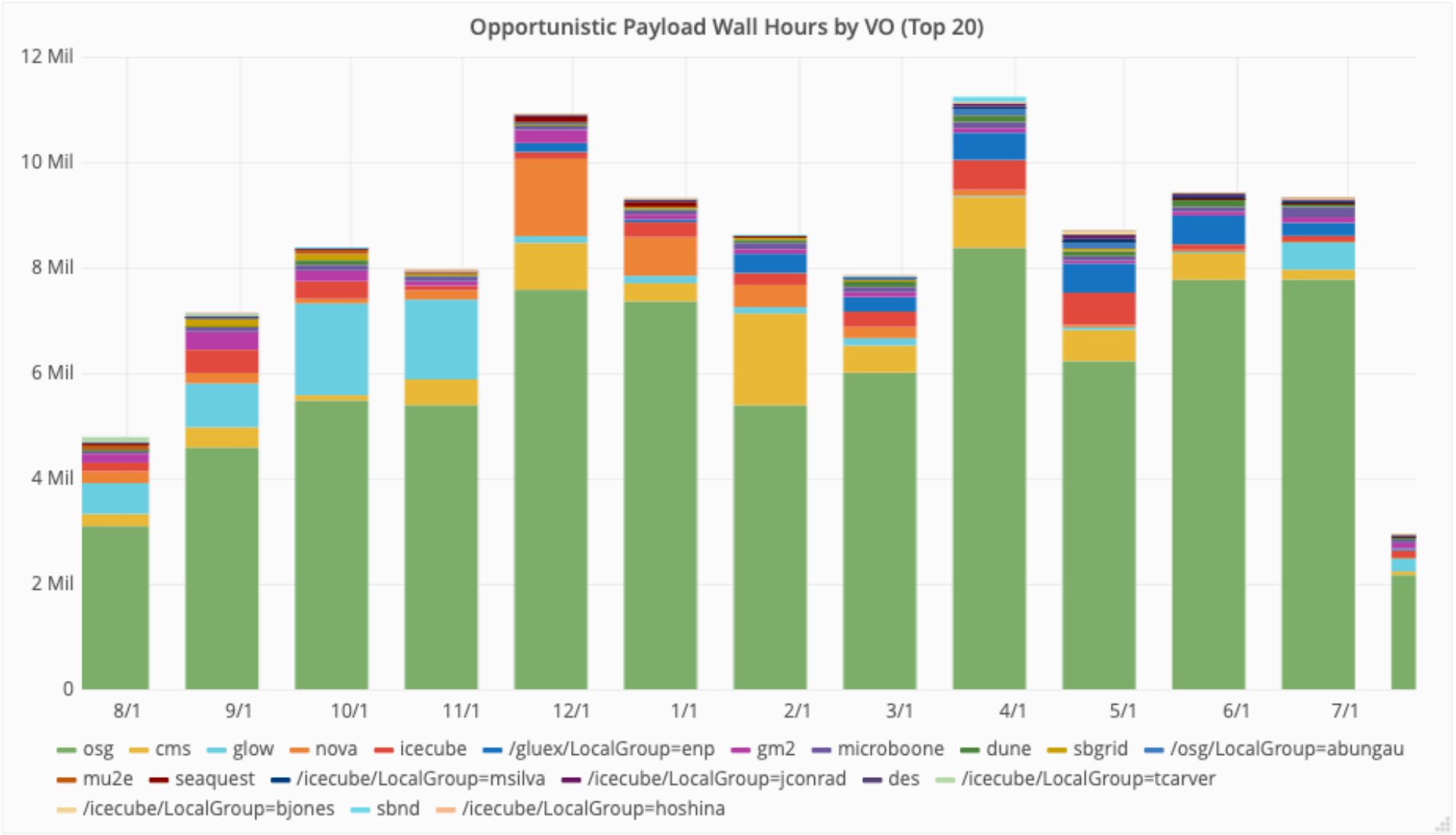


Computing for All of Science

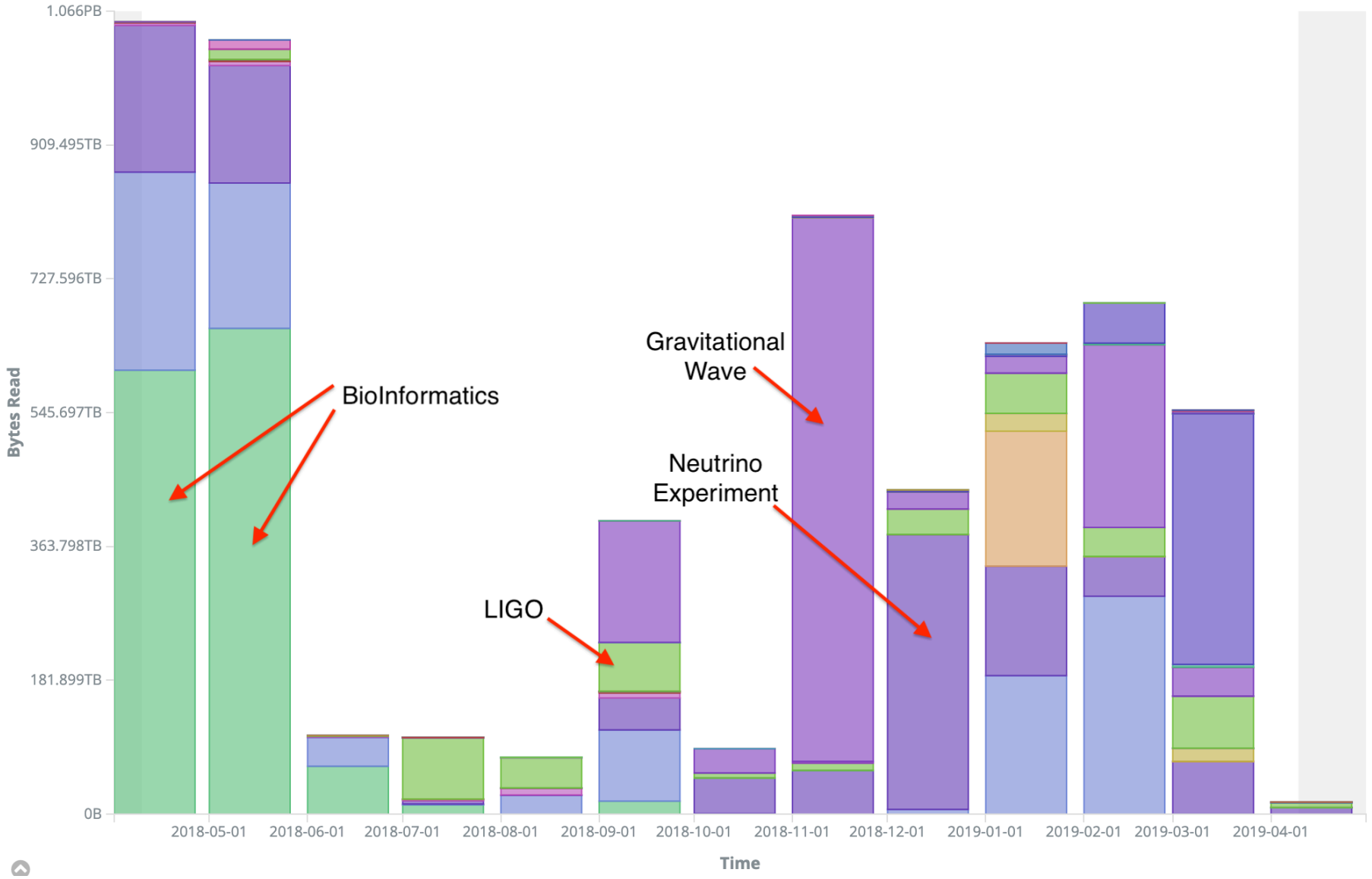


Open Science Grid

Computing for All of Science



StashCache Data Transfers



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Has Anyone Noticed?

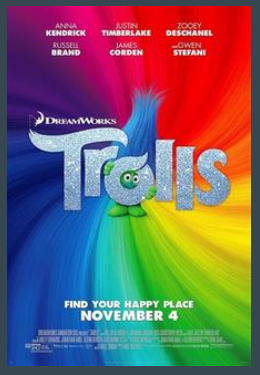
- "... many fields today rely on high-throughput computing for discovery." (p. 2)
- "**Recommendation 2.2.** NSF should … broaden the accessibility and utility of these large-scale platforms by allocating high-throughput as well as high-performance workflows to them." (p. 3)

National Academies of Sciences, Engineering, and Medicine. (2016). *Future Directions for NSF Advanced Computing Infrastructure to Support U.S. Science and Engineering in 2017–2020*. Washington, DC: The National Academies Press. https://doi.org/10.17226/21886.

HTC Beyond Research

DreamWorks

Using HTCondor Since 2011



Open Science Grid

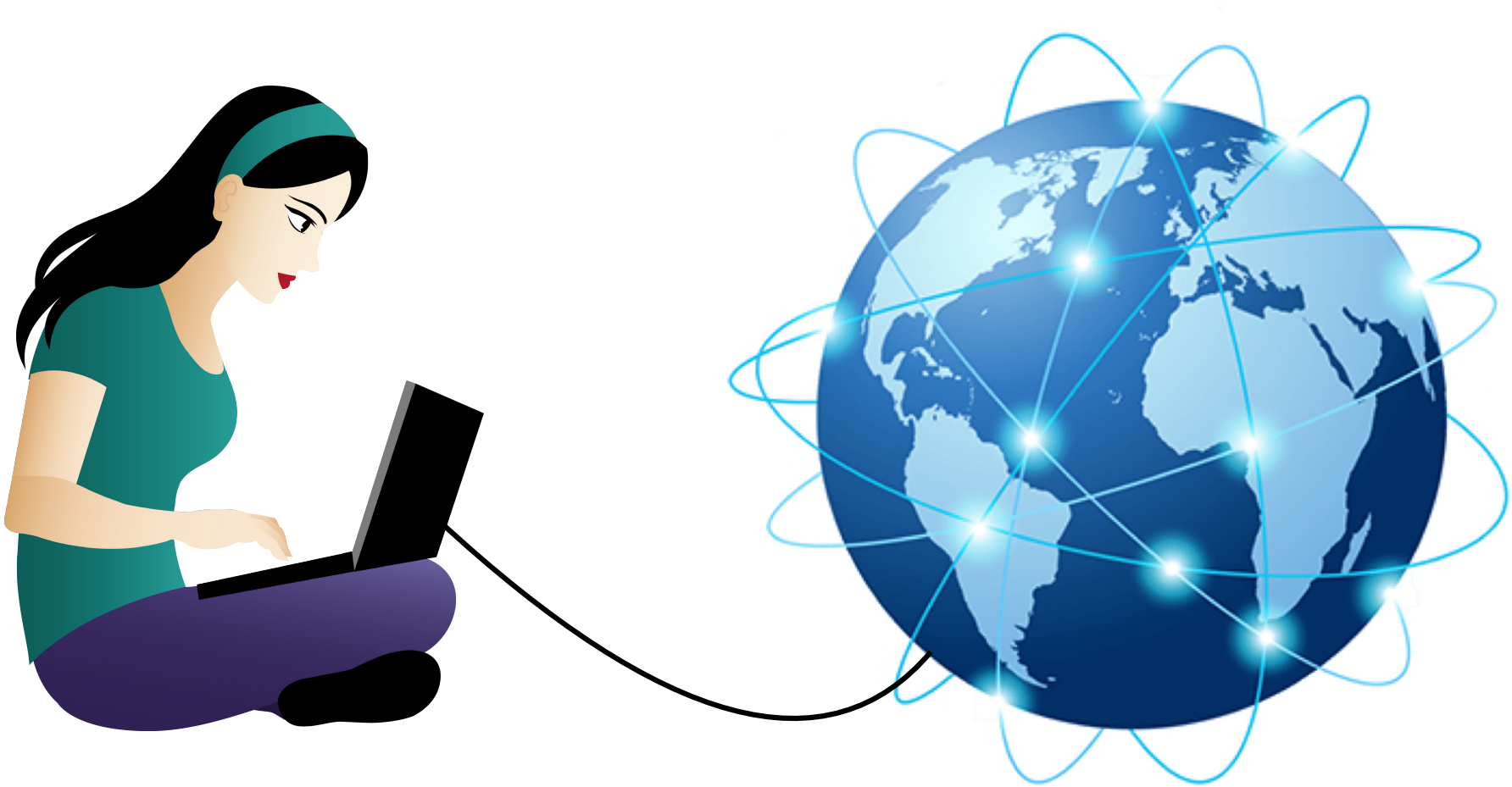
Who's Next?

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!

Conclusions

Submit Locally, Run Globally



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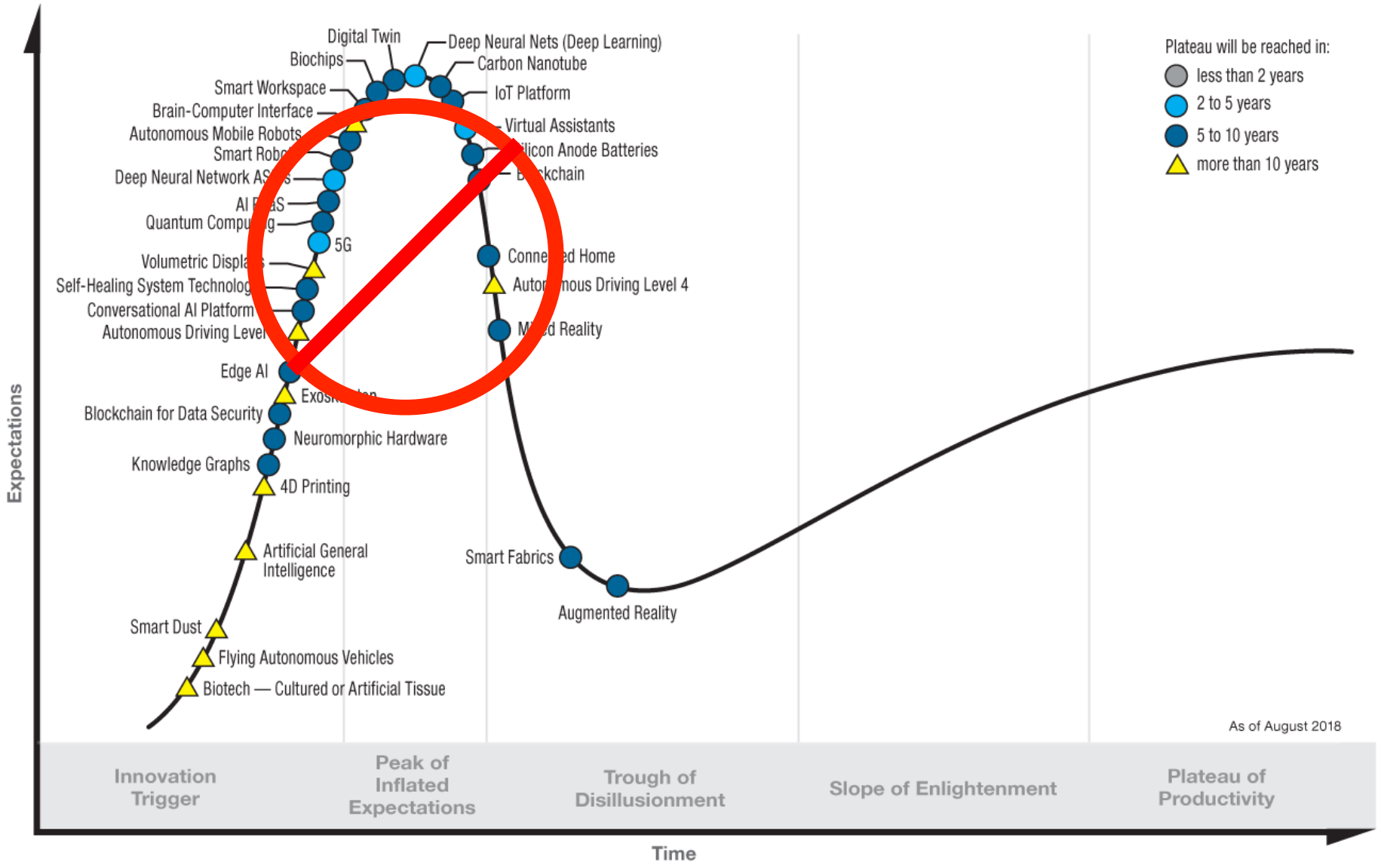
Temper Hype With Principles



Be Part of the Community

Thank You!