Development and Requirements for an Arizona Robotic Telescope Network

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for Steward Observatory

Kuiper 61”
Mt Lemmon, AZ

Bok 90”
Kitt Peak, AZ

VATT 1.8m
Mt Graham, AZ

and more ...

Why astronomers may want and need queue and automated operation of medium size telescopes

Science cases: transients, time-variables, large surveys.
LSST will generate an incredible stream of alerts: even with strong filtering, getting science from these will be limited by followup resources, and current ad hoc organization of follow-up between observatories and telescopes won't be able to keep up.

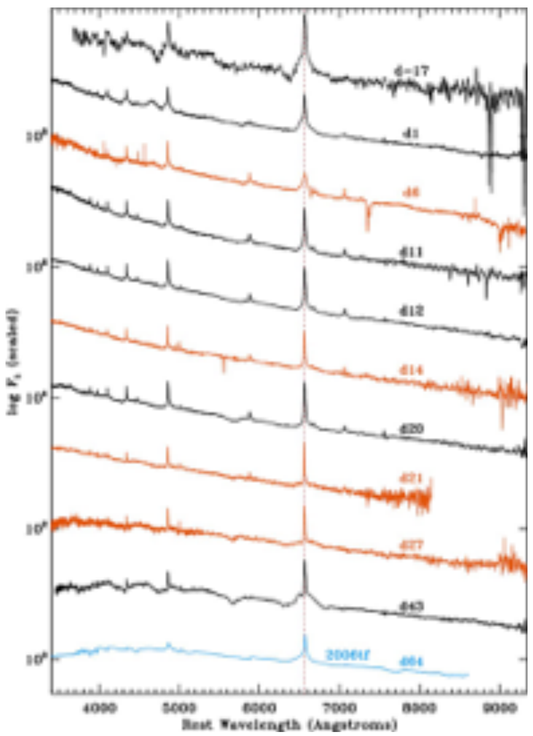
Pressure on 1-3m telescopes to stay productive and open.
Increase efficiency; multiple programs/night.
Classical observing = takes lots of people power, observer decision-making.

Classical telescope scheduling

		Lunar	MMT				90"				61"				60"	
		Phase	Observers	Prog	Instr	Cage	Observers	Prog	Instr	Cage	Observers	Prog	Instr	Cage	Observers	Prog
1	Th	-10.7	SAO		MMIRS	f/5	McMillan et al.	S298	90Prime	P	TBS				Christensen & Larson	L84
2	F	-9.7	"		"	"	Green et al.	S333	B&C	f/9	N. Smith et al.	S303	Mont4K	f/13.5	"	"
3	Sa	-8.7	Mommert et al.	S296	"	"	N. Smith et al.	S303	"	"	"	"	"	"	"	"
4	Su	-7.7	"	"	"	"	"	"	"	"	Green et al.	S333	"	"	"	"
5	M	-6.7	DIR	DIR	SPOL	f/9	Zhao et al.	GTO	90Prime	P	TBS				"	"
6	Tu	-5.7	DIR	DIR	"	"	"	"	"	"	TBS				"	"
7	W	-4.7	Zabludoff et al.	S363	"	"	"	"	"	"	Green et al.	S333	Mont4K	f/13.5	"	"
8	Th	-3.7	"	"	"	"	"	"	"	"	TBS			"	"	"
9	F	-2.7	N. Smith et al.	S303	Blue	"	"	"	"	"	N. Smith et al.	S303	"	"	"	"
10	Sa	-1.7	Holberg et al.	S305	"	"	"	"	"	"	"	"	"	"	"	"
11	Su	-0.7	"	"	"	"	"	"	"	"	McCarthy et al.	L237	Camp	"	"	"
12	M	0.3	N. Smith et al. / SAO	S303 /	"	"	"	"	"	"	P. Smith et al.	S290	SPOL	"	"	"

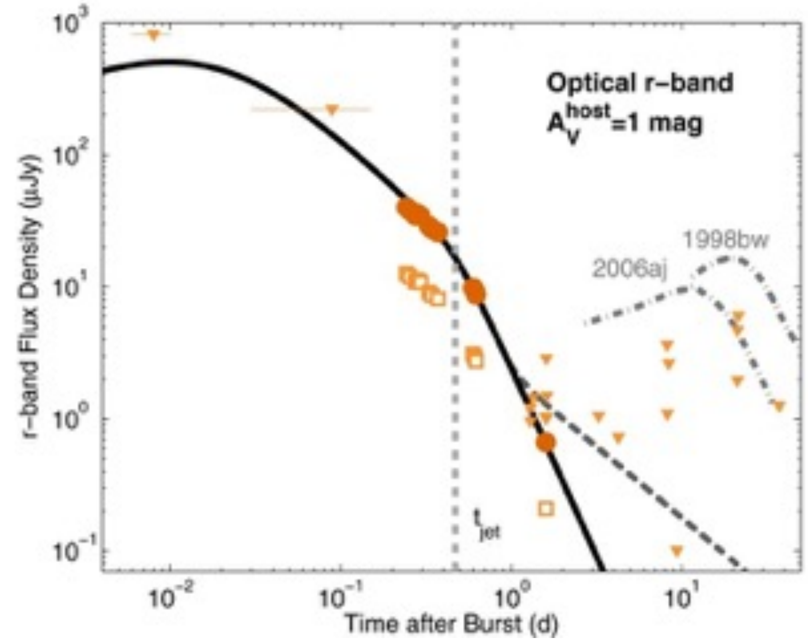
Some example science cases:

Supernova monitoring



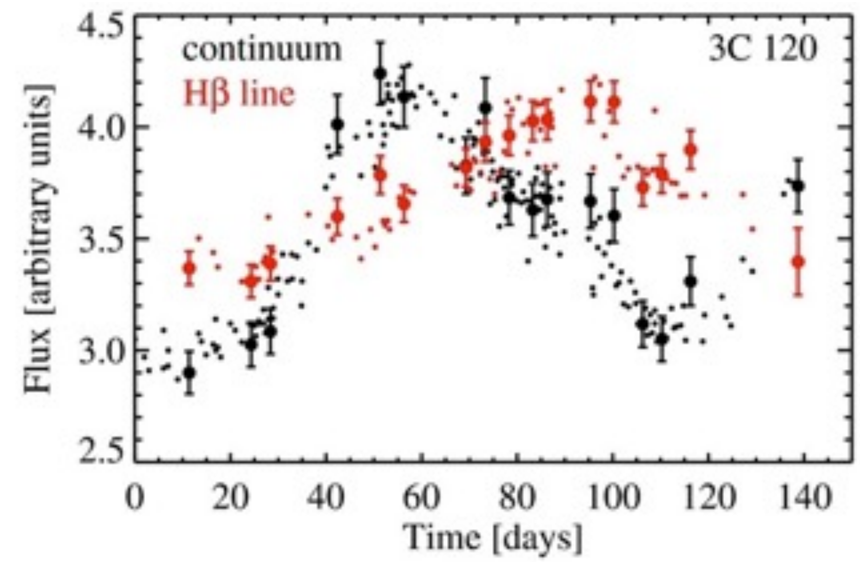
Spectral evolution of
stellar explosions
N. Smith (SO) et al 2014

Transient classification



Fast response observations of optical
afterglow of gamma-ray burst
W. Fong (SO) et al 2014

Black hole reverberation mapping



Time delay between light curves of
accretion regions of SMBH
Y. Shen et al, incl I. McGreer (SO)

Each of these programs has different requirements for trigger/response time, cadence, sensitivity, imaging and spectroscopy.
But they can share common telescopes, instruments, and nights.
Queue observation allows these and other programs to share time.
Automated/assisted scheduling makes queueing practical.

Creating a network from UA telescopes

Kuiper 1.5m
optical/IR imaging

Bok 2.3m
wide field opt imaging

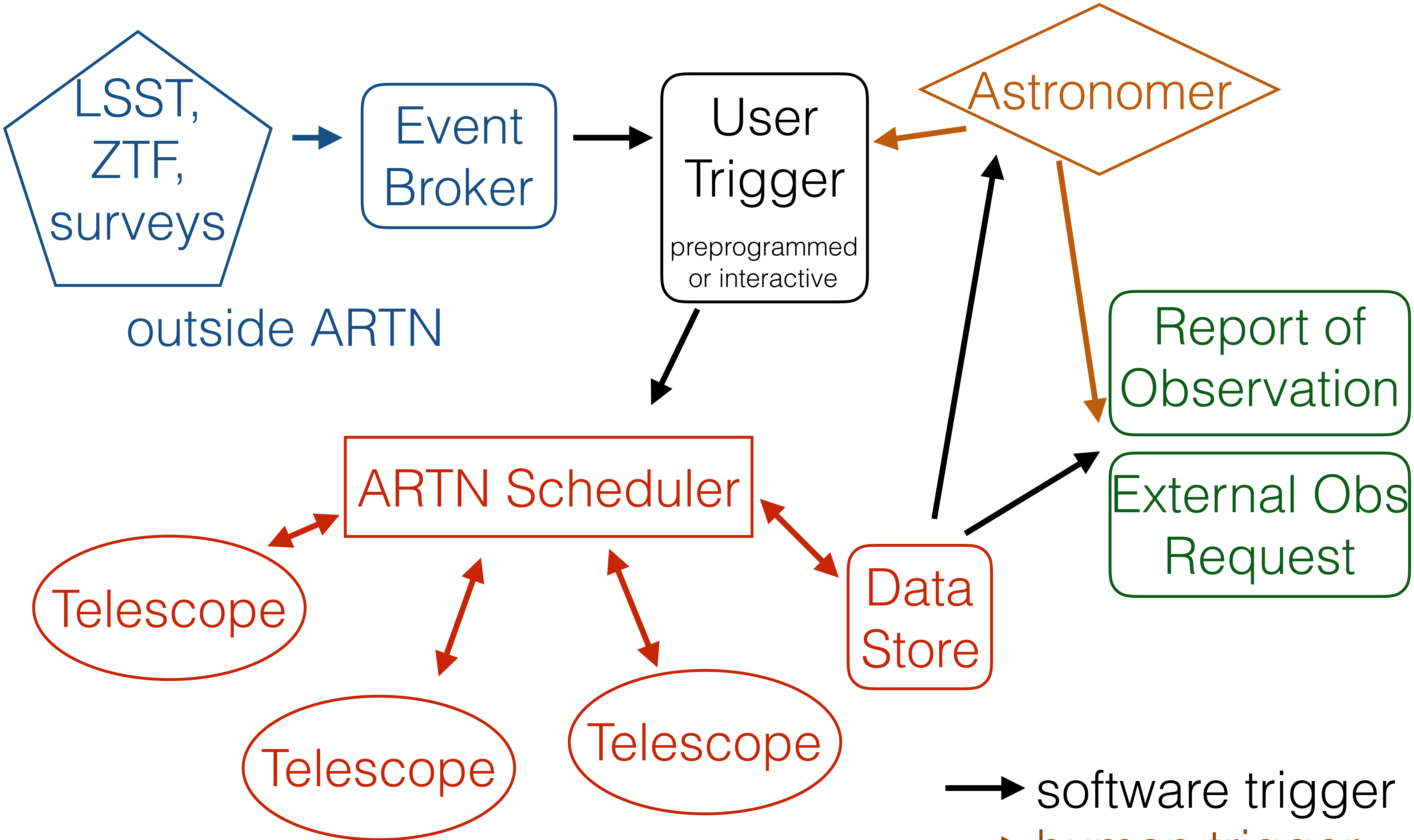
VATT 1.8m
optical spectroscopy

+

MMT 6.5-m, and others

Steward/UA operates or shares in several medium-size telescopes with modern instruments on high, dark sites that could be queue/remote/automated.
Plus larger telescopes that could take observation requests,
and smaller survey telescopes.
Can dedicate telescopes + instruments: simultaneous optical, IR, spectroscopy;
have observations on one telescope cue / trigger other observations.
We could construct a **network** of heterogeneous telescopes / instruments.
We need to design / specify the **science and technical requirements and APIs** for the network manager and interfaces between network, telescopes, and users.

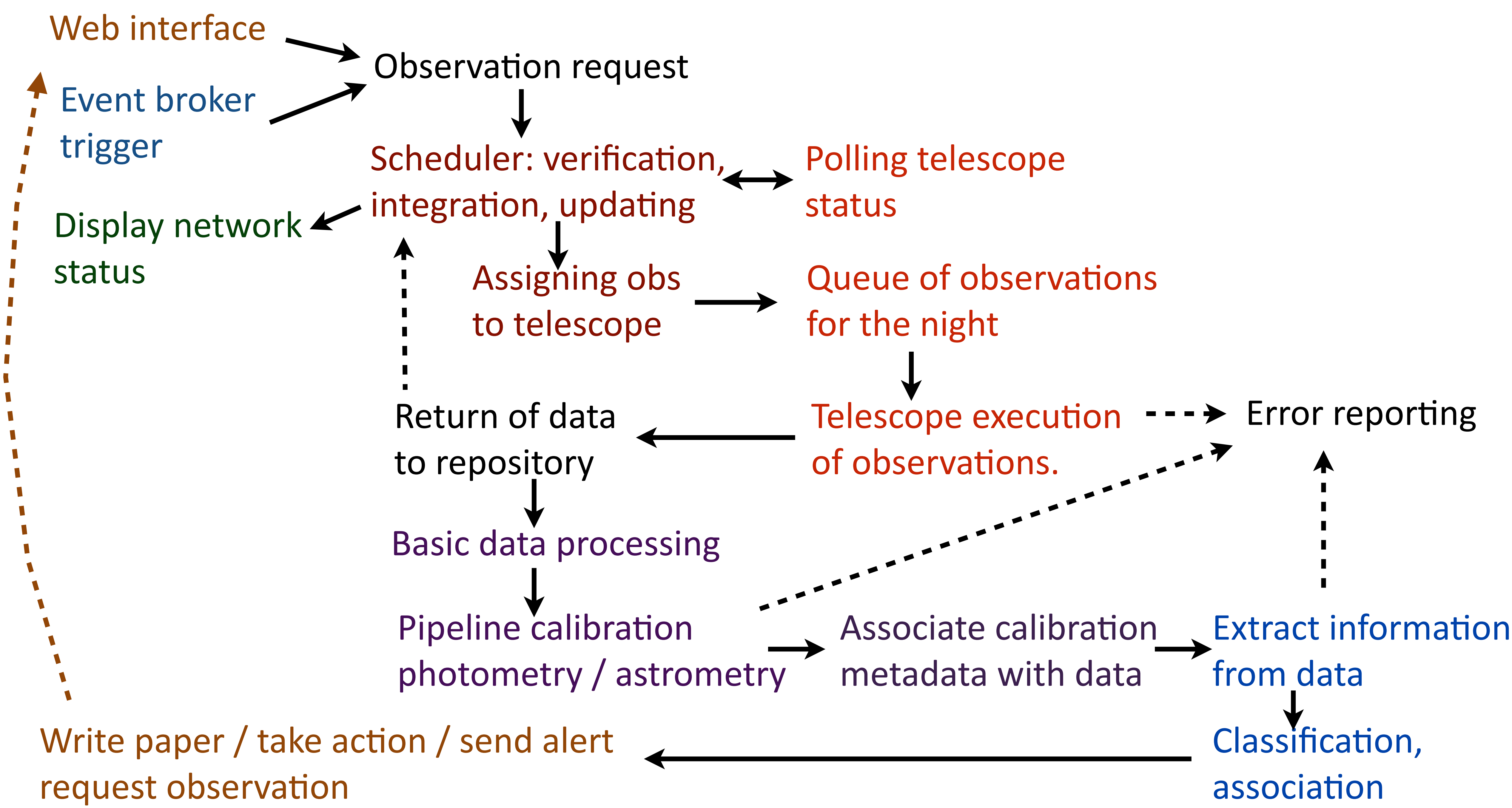
Potential network architecture sketch



Need to design the interfaces in the arrows!

Automating the observation life cycle - incrementally

Divide problem into segments: define requirements for chunks of system and transfer responsibility from people to the system in stages. Goal: take expertise from observers / data processers' heads into an integrated system.



Challenges in building a network and automation

UA telescopes still operate mostly classically scheduled and mostly without automated reduction pipelines. Exceptions include SuperLOTIS, CSS, surveys with scripted observing, and queues on large telescopes.

Need to transition to queue / remote / automated operation without loss of capability to observers, and insure safety, avoid risk to instruments, don't let it rain on the telescope. Replacing or even simplifying the task of trained observers is complex. Work and cost is largely in software, decision-making, pipelines, integration with existing hardware. Building a heterogenous, intelligent network is an open problem.

We need to manage automating incrementally, without making design decisions that limit the capability of the network or make adding telescopes difficult. So think about:

- Science requirements: what your program will need to observe
- Technical requirements that flow from these: e.g. depth, cadence, response time, dynamic scheduling, imaging / spectroscopy, calibrations, multiple telescopes, API for observation requests, safety, weather reports …
- Data processing requirements
- How components of the network should talk to each other and to the outside world, e.g. how observations are triggered, schedule computation, how telescopes report completed observations, …