Scheduling Observations on the LCOGT Network

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Telescopes from Afar, March 3 2011, Hawaii
The LCOGT network

- Will have approximately 80 data sources around the globe
  - 8 sites – 4 in northern ring and 4 in southern ring
  - Two 2.0m telescopes
  - ~42 -- 1.0m telescopes and 0.4m telescopes at each site, plus all-sky, extinction, and IR monitors.
- Everything must be fully robotic
  - Telescopes
  - Enclosures
  - Instruments
  - ...
- Central location for users to specify observations
Scheduling - why bother?

- You've got a network of robotic telescopes
- You want to get observations. Right?
- ...
Scheduling - why bother?

- You've got a network of robotic telescopes
- You want to get observations. Right?
- ...

Not really!

What you really want is for the network to
- get the most important science programs done.
- even (especially!) the complicated ones
- deal with bad weather.
- deal with telescope downtime.
- be efficient.
Top-level Architecture

- Proposal/TAC
  - Schedule an Observation
  - Obtain the Observation
  - LCOGT Internal Science
  - Archive, Pipeline, Public Access
  - Calibrate, Quick-Look, QA

To Outside World
LCOGT Software Components

Diagram version: 0.9.1 (FBD 20090211)
I want a picture of Jupiter next Monday at 9
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Hmm, Jupiter will be visible from Site A next Monday at 9, I'll slot it in the plan.

Observation Database

Las Cumbres Observatory Global Telescope Network
I want a picture of Jupiter next Monday at 9.

Hmm. Jupiter will be visible from Site A next Monday at 9, I'll slot it in the plan.

Plan for Telescope B at Site A:
- Monday @8: Fornax
- Monday @9: Jupiter
- Monday @10: Taurus
I want a picture of Jupiter next Monday at 9.

Hmm, Jupiter will be visible from Site A next Monday at 9, I'll slot it in the plan.

Plan for Telescope B at Site A:
- Monday @ 8: Fornax
- Monday @ 9: Jupiter
- Monday @ 10: Taurus

Got it! Telescope B covering Jupiter @ 9!

Las Cumbres Observatory Global Telescope Network
Plan for Telescope B at Site A:
- Monday @8: Fomax
- Monday @9: Jupiter
- Monday @10: Taurus

Got it! Telescope B covering Jupiter @ 9!
I want a picture of Jupiter next Monday at 9.

Observation Database

Hmm, Jupiter will be visible from Site A next Monday at 9, I'll slot it in the plan.

Plan for Telescope B at Site A:
Monday @ 8: Fomalhaut
Monday @ 9: Jupiter
Monday @ 10: Taurus

Got it! Telescope B covering Jupiter @ 9!

Site A, Telescope

Site Agent

Las Cumbres Observatory Global Telescope Network
Plan for Telescope B at Site A:

- Monday @8: Fomax
- Monday @9: Jupiter
- Monday @10: Taurus

Got it! Telescope B covering Jupiter @9!
POND

- Proposal and Observation Network Database
- Clearinghouse for all things observed
- Responsibilities
  - Capture observing proposals submitted by users
    - Input to seasonal planner
  - Capture output of Seasonal Planner
    - also input to Monthly Planner
  - Capture output of Monthly Planner
    - also input to Adaptive Scheduler
  - Capture output of Adaptive Scheduler
    - used as input to Site Agent
  - Provide an API for accessing each data type
  - Provide an admin level UI
POND Implementation

• Django Database
  o Python WebApp Framework
  o MySQL under the hood
  o Leverage admin interface
  o Leverage database query API

• POND Client
  o Protocol Buffer transport layer
  o Client side data mapped to database schema
  o Thin client architecture
  o Users don't interact with the database directly
  o Multiple language implementations possible with minimal investment
Seasonal Planner

• Provides coarse, long-range planning at the program level
  • Takes set of programs and associated meta-information
  • Calculates approximate observing hours for each program at each site
• Constrains and informs the detailed planning cycle

• LCOGT is a private institution. Order starts at this phase: avoid over-subscription.
Seasonal Planner

- Initial Implementation
Seasonal Planner

• Initial Implementation
Seasonal Planner

- Initial Implementation
Monthly Planner

• Takes global program guidelines from Seasonal Planner

• Constructs a detailed plan for the network
  • Individual observations at each telescope
  • One month window
  • Recomputed daily based on current status of programs
Monthly Planner

- Plug-in Algorithm architecture
- Start simple, and iteratively improve
Adaptive Scheduler

- Takes the plan from the Monthly Planner
- Constructs tentative schedule for one night given current site status
- Sends the night’s schedule to each Site Agent

- Receives real-time updates from each Site Agent
  - Observation completion state
  - Site conditions – seeing, weather, telescope status, etc.
- Recomputes schedule as necessary, again real-time.
Site Agent

• Gateway between the LCOGT network and each site

• Responsibilities
  o Receive and cache site wide observing schedule
  o Monitor run time variable observing constraints
    ▪ e.g. seeing, cloud
  o Enforce observing schedule
  o Forward observing requests to each telescope’s Observation Sequencer
  o Monitor observation progress/completion
  o Forward observation state to scheduler
  o Aggregate and forward telemetry to scheduler
  o Zap errant observing ‘molecules’ (scripts.)
Successful Observation
Overridden Observation
Network Outage

Network Down

Network Up
Where are we at with all this?

- Telescope and Instrument Control Systems – *Implemented*
- Telescope Observation Sequencer – *Implemented*
- Site Agent – *Implemented*
- Adaptive Scheduler – *Partially Implemented*
- Monthly Planner – *Designed*
- Seasonal Planner – *Partially Designed*
- Proposals & Observations Network Database (POND) – *Implemented*
What we are not doing:

• Distributed control
• Worrying about oversubscription
• Early binding of ideas: Throw it away again, Sam.
• Optimization
• Fancy UI’s
• Trying to solve the Turing problem too soon. Just observe for now.
• Sys Admin wizardry. Every file pushed from SVN, MAC address reservations for provisioning, uniform PXE boot. IDENTICAL systems.
What we are doing:

- Use common tools: Java, Jython, DJANGO, Google Web Toolkit, Linux (Centos). JADE publish and subscribe. Unified MySQL database with re-sampling and aging. Build a robust platform.

- Everything is www based. Android ready cocktail party observing is possible.

- We even have a fits viewer that is www based and fast.

- Have large SCYLD (Beowulf) 512 CPU cluster at SBA, 64-128 CPUs at each site. Treat computing cycles as free. PYTHON for main science codes, Java on Centos for ‘system’ programming.

- Professional computer scientists teamed with Astros.

- TPOINT and tpstk (RAL) are only major outside codes. So in principle we understand every line of code. (And we have this bridge for sale…) ORAC-DR for initial pipeline.
What you* can do:

- Execute fairly arbitrary jobs on site cluster.
- Schedule complex Python (pre-simulated and tested) observing scripts, which include data reduction and analysis steps, at site. Interaction with core system is via a restricted set of class interfaces.
- Commission from Afar!
- Citizen Scientists:
  - Data and execution environment available on Google Application Engine. (Volume accounts managed there.)
- * participants in Key Projects.
Got Open?

- Everything LCOGT engineers is available to anyone, no restrictions except a GNU style license, with the exception of the information from RAL and TPSOFT.

- This means code, blueprints, CAD models, schematics, you name it.

- Please do not call for support! (We are pretty busy.) First instance of IP export: Vendor changed the design and broke it 😞
We keep you in the dark.