PUG 2021

Pegasus Users Group

MEETING

PUG 2021

Weather Feature Extraction on the Academic Cloud for Drone Route Planning

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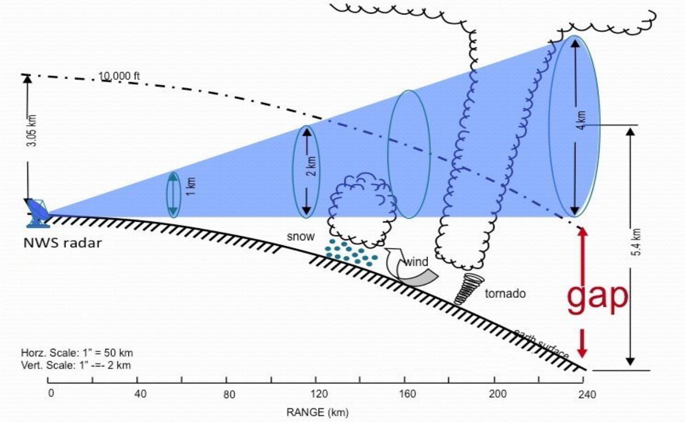
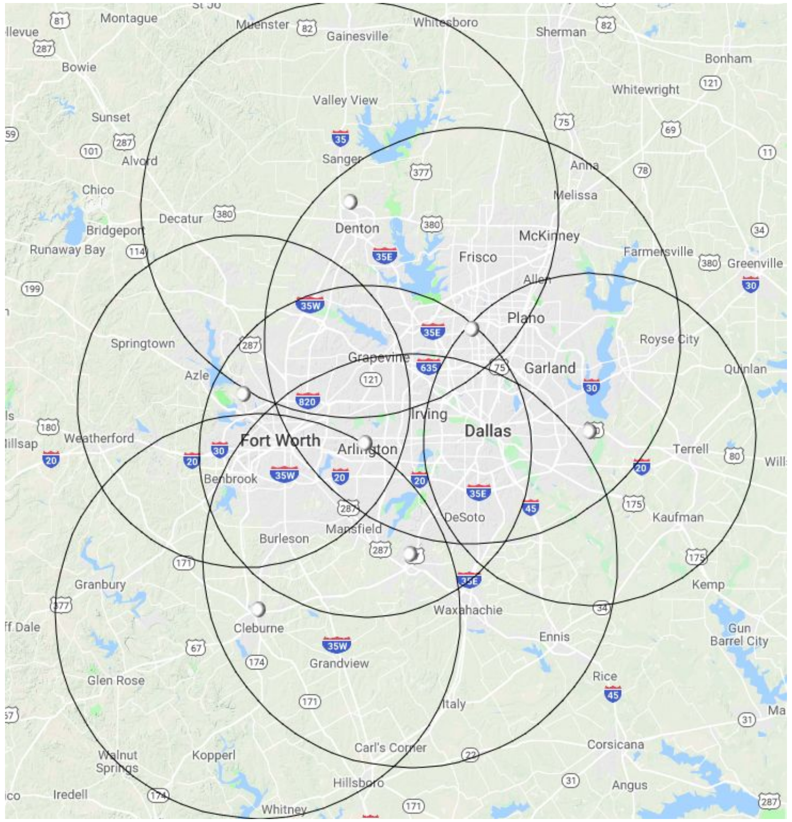
2/19/2021

CASA Radar Network



- Next Generation Weather Radars (NEXRAD)
  - High power, long range
  - Limited ability to observe the lower part of the atmosphere because of the Earth's curvature

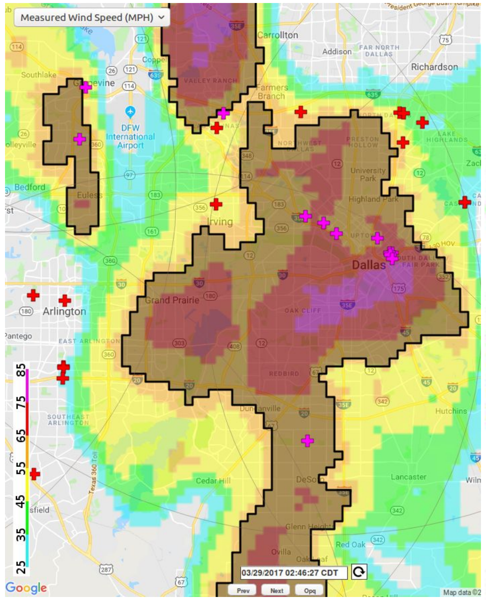


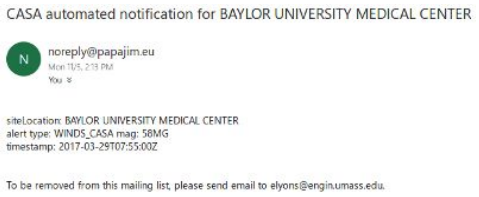
- CASA
  - Network of short range Doppler radars
  - Fast updating, near to the ground observations
  - Overlapping coverage provides multiple views of weather feature

Drone Guidance Application

- Unmanned aviation systems (UAS) is a rapidly growing industry
- Small aircraft are sensitive to weather and CASA seeks to provide customized information to minimize weather risk
- Compute and network intensive workflows associated with processing CASA radar data and forecast models at various timescales
- Uses the academic cloud, ExoGENI and Chameleon, for data processing and dynamically created private layer 2 networks
- Implement network-aware workflow scheduling, predictions and ensemble mechanisms using the Pegasus Workflow Management System (WMS)

CASA Wind Contouring Data Processing Workflow



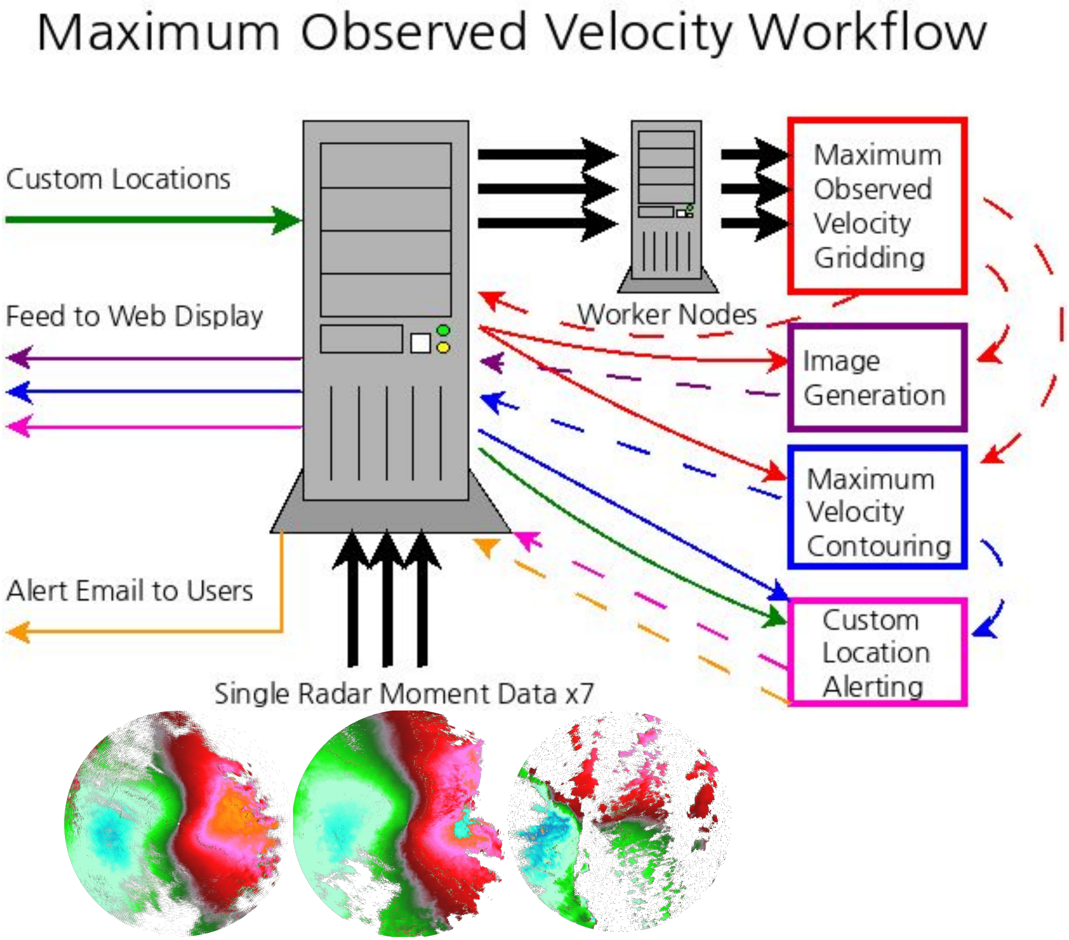


CASA automated notification for BAYLOR UNIVERSITY MEDICAL CENTER

noreply@papajim.eu
Mon 11/5, 2:13 PM
You

siteLocation: BAYLOR UNIVERSITY MEDICAL CENTER
alert type: WINDS_CASA mag: 58MG
timestamp: 2017-03-29T07:55:00Z

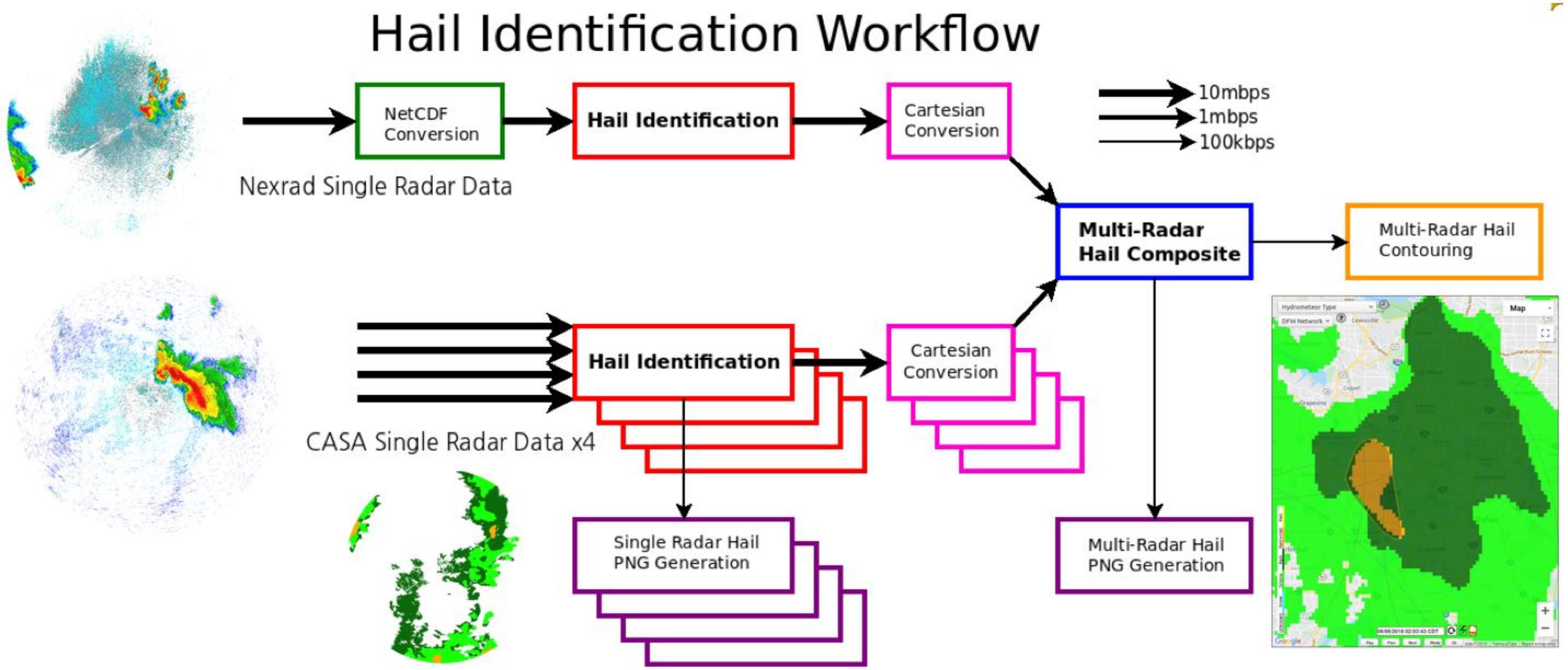
To be removed from this mailing list, please send email to elyons@engin.umass.edu.



Maximum Observed Velocity Workflow
Custom Locations
Feed to Web Display
Alert Email to Users
Worker Nodes
Maximum Observed Velocity Gridding
Image Generation
Maximum Velocity Contouring
Custom Location Alerting
Single Radar Moment Data x7

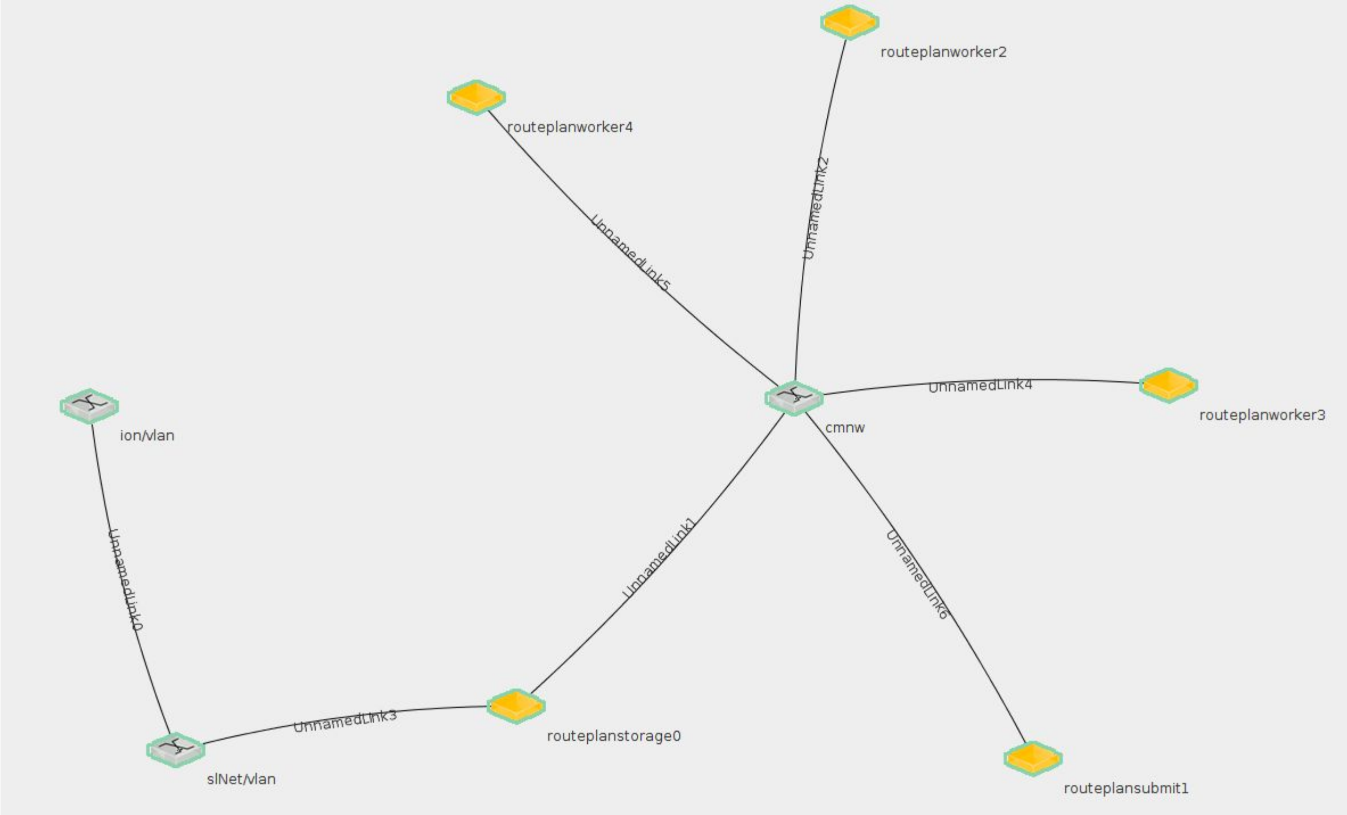
- Ingests compressed data from 7 radars
- Combine into grid of maximum observed wind speed
- Generate combined radar image
- Compute wind contours with velocity thresholds
- Send alerts based on user locations

CASA Hail Data Processing Workflow


Hail Identification Workflow
NetCDF Conversion
Hail Identification
Cartesian Conversion
10mbps
1mbps
100kbps
Nexrad Single Radar Data
Multi-Radar Hail Composite
Multi-Radar Hail Contouring
Hail Identification
Cartesian Conversion
CASA Single Radar Data x4
Single Radar Hail PNG Generation
Multi-Radar Hail PNG Generation

- Ingest compressed data from 4 CASA radars
- Collect Nexrad single radar data
- Hail event identification
- Combine hail data from multiple radars
- Compute hail contouring
- Generate combined radar image

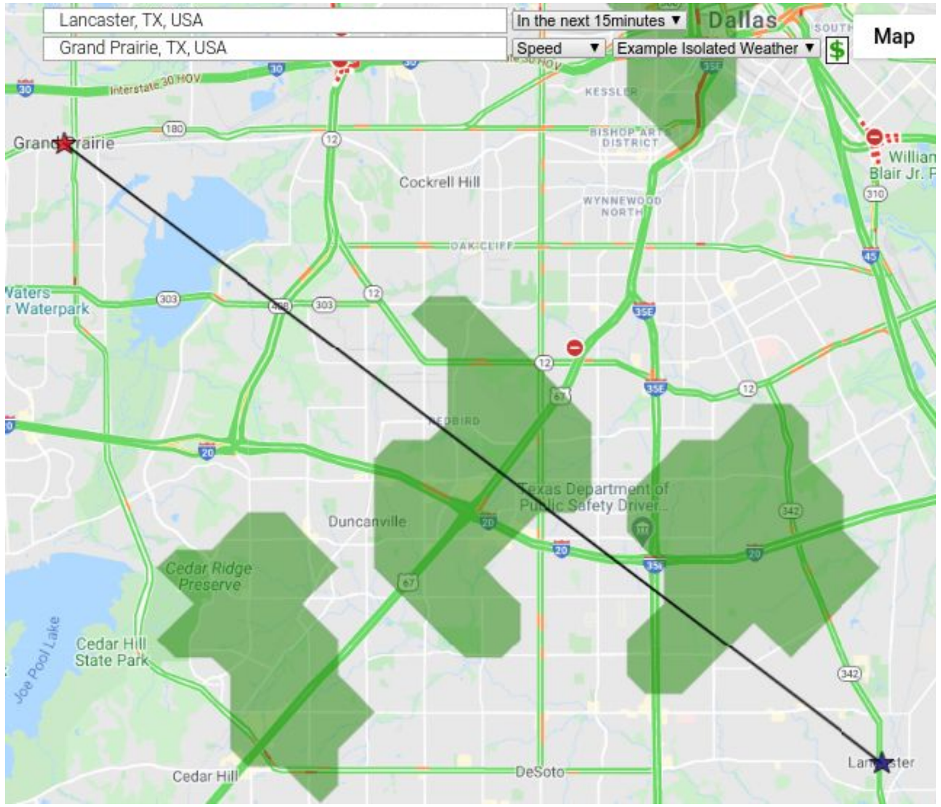
Sample Processing Architecture



- Layer 2 AL2S network linked to a dedicated portal server
- Shared NFS storage node acting as a network bridge and container/data repository
- Pegasus submit node orchestrating workflows and serving as HT Condor master
- HT Condor worker node pool

Drone Route Planning Web Application

- Select Start and End Point
- Assign a vehicle type with weather parameters
- Assign some risk parameters
- Pass submitted flight to a flight database
- Generate routing request
- Return routed flight, or advisory that the flight is not advisable



Lancaster, TX, USA

Grand Prairie, TX, USA

In the next 15minutes ▾

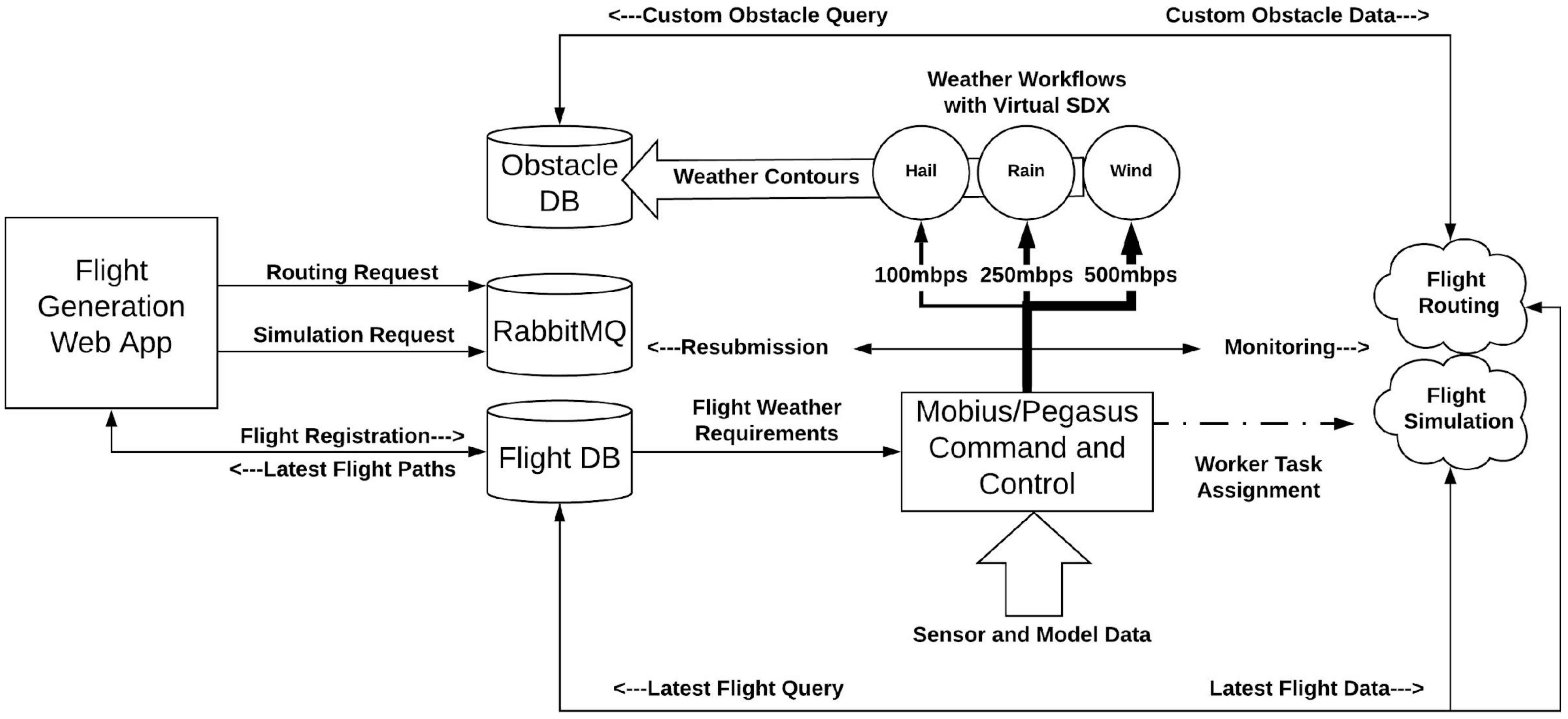
Speed ▾

Example Isolated Weather ▾

$

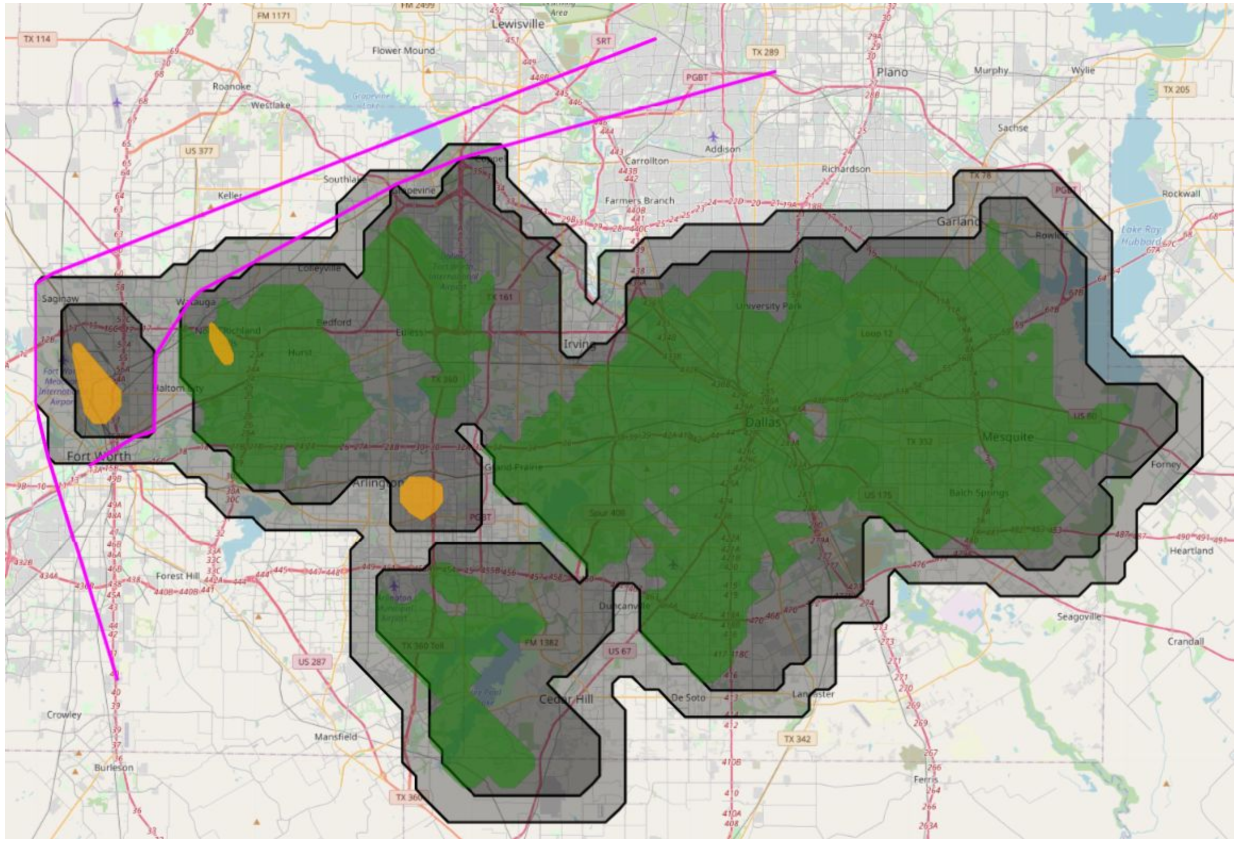
```
"properties":{
"eventName":"VA NORTH TEXAS AT DALLAS TO
PALO PINTO GENERAL HOSPITAL_2020-09-08T19:19:22Z",
"startTime":"2020-09-08T19:19:22Z",
"endTime":"2020-09-08T20:53:57Z",
"products":[
{"hazard":"HAIL_CASA","parameters":[{"distance":0,"distanceUnits":"kilometers"}]},
{"hazard":"RAIN_RATE_CASA","parameters":[{"thresholdUnits":"inph","distance":3,"distanceUnits":"kilometers","threshold":1,"valueField":"RainfallRateLevel"}]},
{"hazard":"STORM_CASA_10","parameters":[{"thresholdUnits":"dBZ","distance":0,"distanceUnits":"kilometers","threshold":30,"valueField":"ReflectivityLevel"}]},
{"hazard":"FORECAST_CASA_30","parameters":[{"thresholdUnits":"dBZ","distance":0,"distanceUnits":"kilometers","threshold":30,"valueField":"ReflectivityLevel"}]},
{"hazard":"WINDS_CASA","parameters":[{"thresholdUnits":"mph","distance":2,"distanceUnits":"kilometers","threshold":25,"valueField":"mag"}]}]}}]
}
```

CASA Flight Routing Architecture



Flight Routing Process

- Latest weather polygons are queried from the obstacle database
- Safety/Uncertainty buffers are added on a per feature basis, and then polygons are merged and regenenerated into master obstacle course, including static areas.
- A graph is created using convex hull points of the master obstacle course
- Modified A* algorithm used to generate the shortest path from the resultant graph
- Results are posted back into the flight database, along with new end time estimate, distance, and cost.

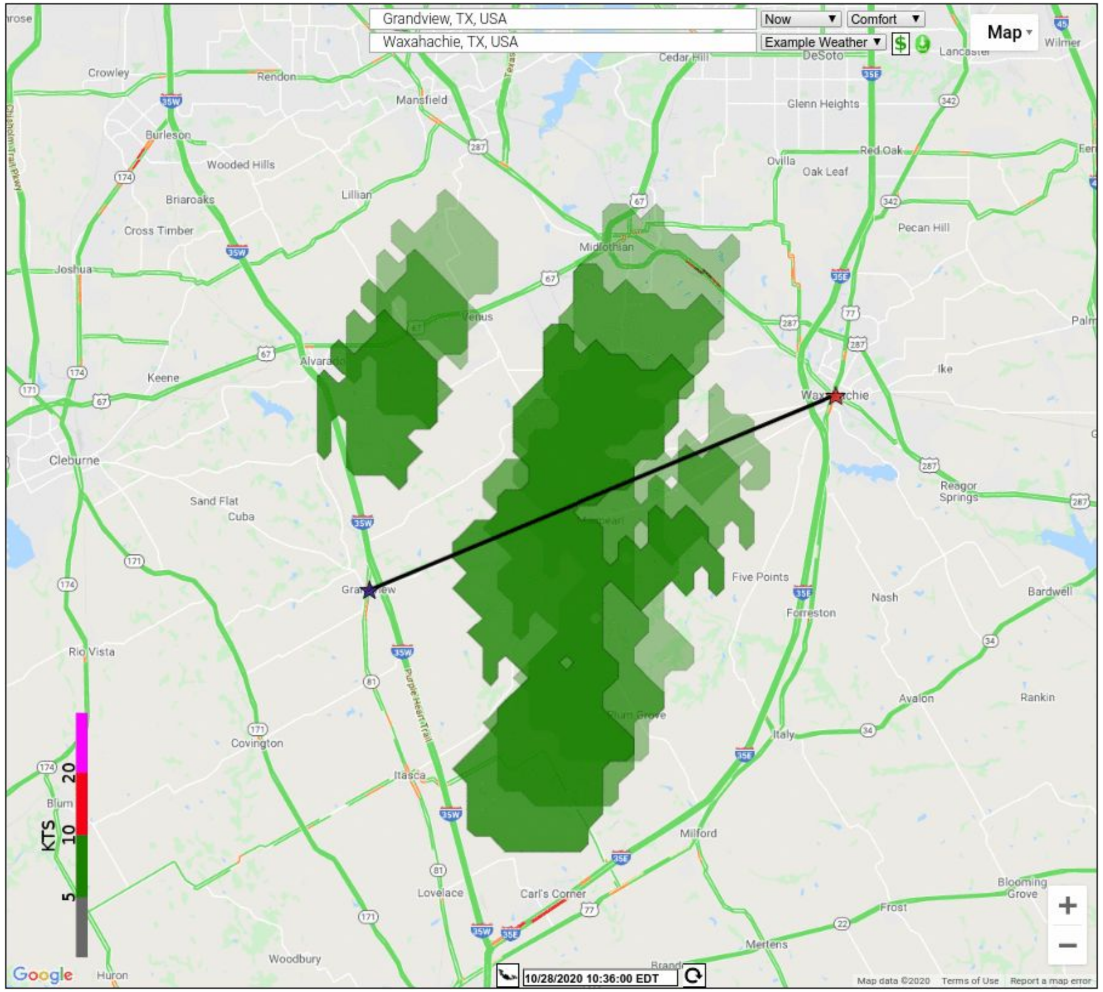


DYNAMO

Dynamic Routing

NSF

- Flights are advanced along their routed paths in realistic ways based on flight speeds.
- Routing occurs on an ongoing basis as the weather observations and forecasts evolve over time
- Forecasts are unpredictable and prone to error! Estimates are constantly evolving.
- Even if operations generally rely on longer term forecast for strategic decisions, they will still have to consider developing, perhaps unexpected weather at flight time and be able to navigate.



Grandview, TX, USA
Waxahachie, TX, USA
Now ▾
Comfort ▾
Example Weather ▾
10/28/2020 10:36:00 EDT

renci

USC Viterbi
School of Engineering
Information Sciences Institute

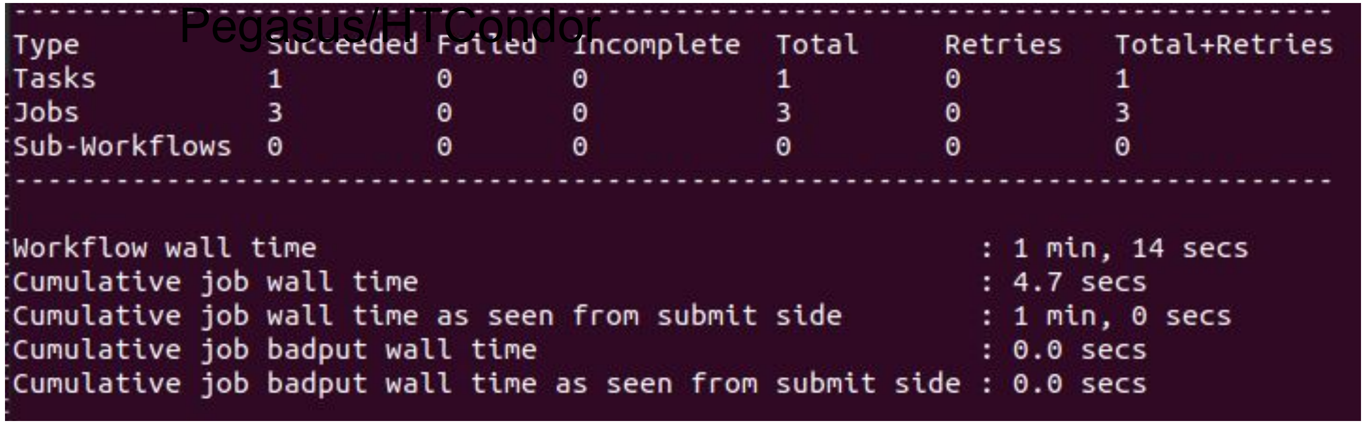
UMass Amherst

RUTGERS

Pegasus/Condor Pros and Cons

- Pro: Seamlessly distributes processing on an arbitrary pool of worker nodes
- Con: Planning and orchestration can take a long time
- Options:
  - Bundle fast workflows together
  - Favor longer running workflows
  - Use Pegasus to assign message queue based listeners that handle the jobs, rather than assigning the jobs directly
  - Use Pegasus for jobs with lower timeliness requirements

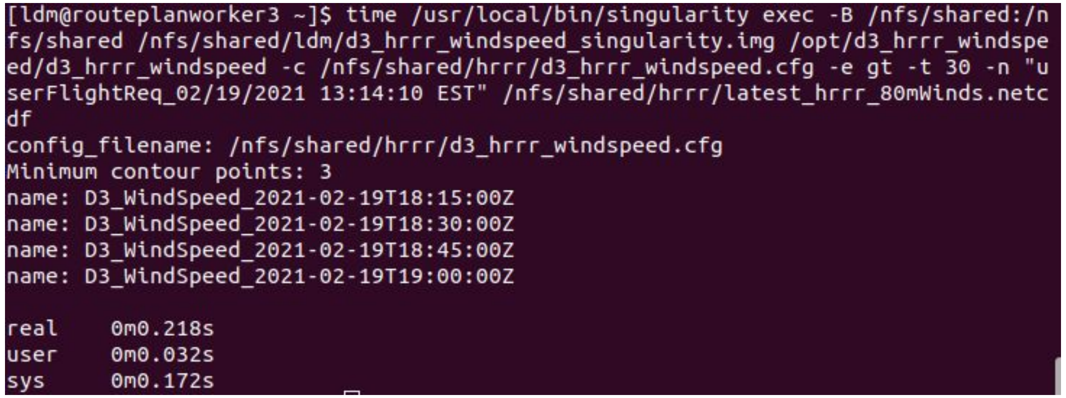
Single, simple job through Pegasus/HTCondor



```
------------------------------------------------------------------------------
Type           Succeeded Failed  Incomplete  Total     Retries   Total+Retries
Tasks          1         0       0           1         0         1
Jobs           3         0       0           3         0         3
Sub-Workflows  0         0       0           0         0         0
------------------------------------------------------------------------------

Workflow wall time                                       : 1 min, 14 secs
Cumulative job wall time                                 : 4.7 secs
Cumulative job wall time as seen from submit side        : 1 min, 0 secs
Cumulative job badput wall time                          : 0.0 secs
Cumulative job badput wall time as seen from submit side : 0.0 secs
```

Same job, executed the same way, manually



```
[ldm@routeplanworker3 ~]$ time /usr/local/bin/singularity exec -B /nfs/shared:/n
fs/shared /nfs/shared/ldm/d3_hrrr_windspeed_singularity.img /opt/d3_hrrr_windspe
ed/d3_hrrr_windspeed -c /nfs/shared/hrrr/d3_hrrr_windspeed.cfg -e gt -t 30 -n "u
serFlightReq_02/19/2021 13:14:10 EST" /nfs/shared/hrrr/latest_hrrr_80mWinds.netc
df
config_filename: /nfs/shared/hrrr/d3_hrrr_windspeed.cfg
Minimum contour points: 3
name: D3_WindSpeed_2021-02-19T18:15:00Z
name: D3_WindSpeed_2021-02-19T18:30:00Z
name: D3_WindSpeed_2021-02-19T18:45:00Z
name: D3_WindSpeed_2021-02-19T19:00:00Z

real    0m0.218s
user    0m0.032s
sys     0m0.172s
```

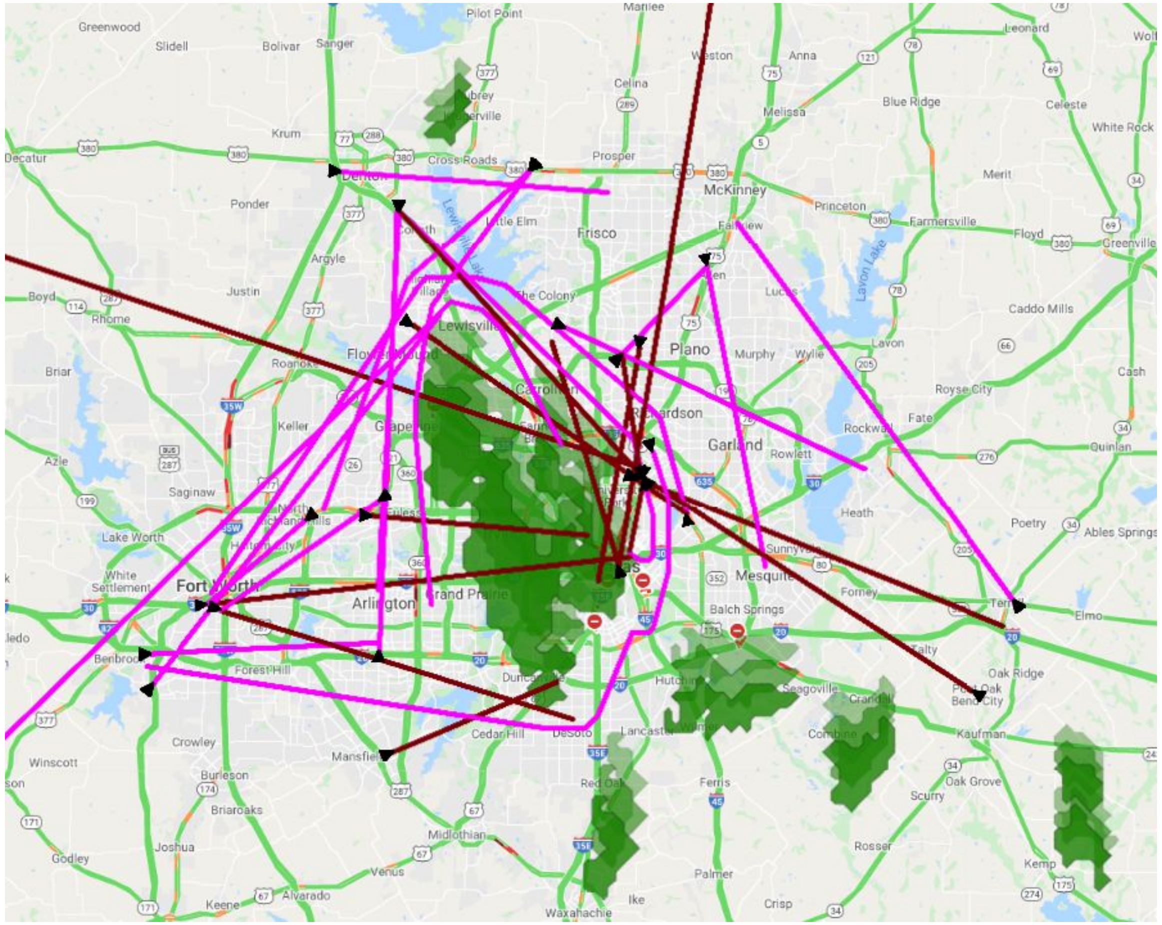
Pegasus/Condor uses Current and Ongoing

- Current use:

- Pegasus jobs contain the super set of all product contour levels for all ongoing flights at all times

- In Development:
- Use Pegasus to analyze ensemble model suites, for which the processes are duplicated for each member, with dependent jobs for overall uncertaintly analysis once all the individual runs have been processed

- Jobs to route all flights as a fleet, and ensure that paths do not intersect in space and time



Requests/suggestions:

REST API for remote job submission

Lightweight options for faster jobs (no checkpointing/reduced metrics/faster planning(?))

Contingency job planning in workflows

Deeper integration with Mobius for resource procurement

Thank You!