Fault Tolerance and Recovery for Grid Workflow Systems

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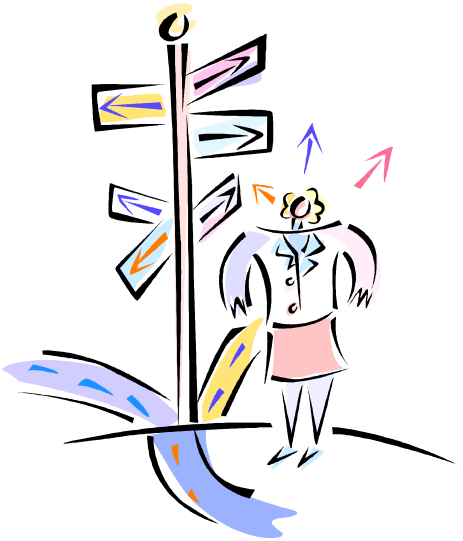
Presentation Outline

- Motivation and rationale
- Fault tolerance and recovery service
- Fault tolerance and recovery algorithms
  - over-provisioning, simple restart, migration
- Proposed next steps
- Demonstration
  - LEAD-VGrADS integration



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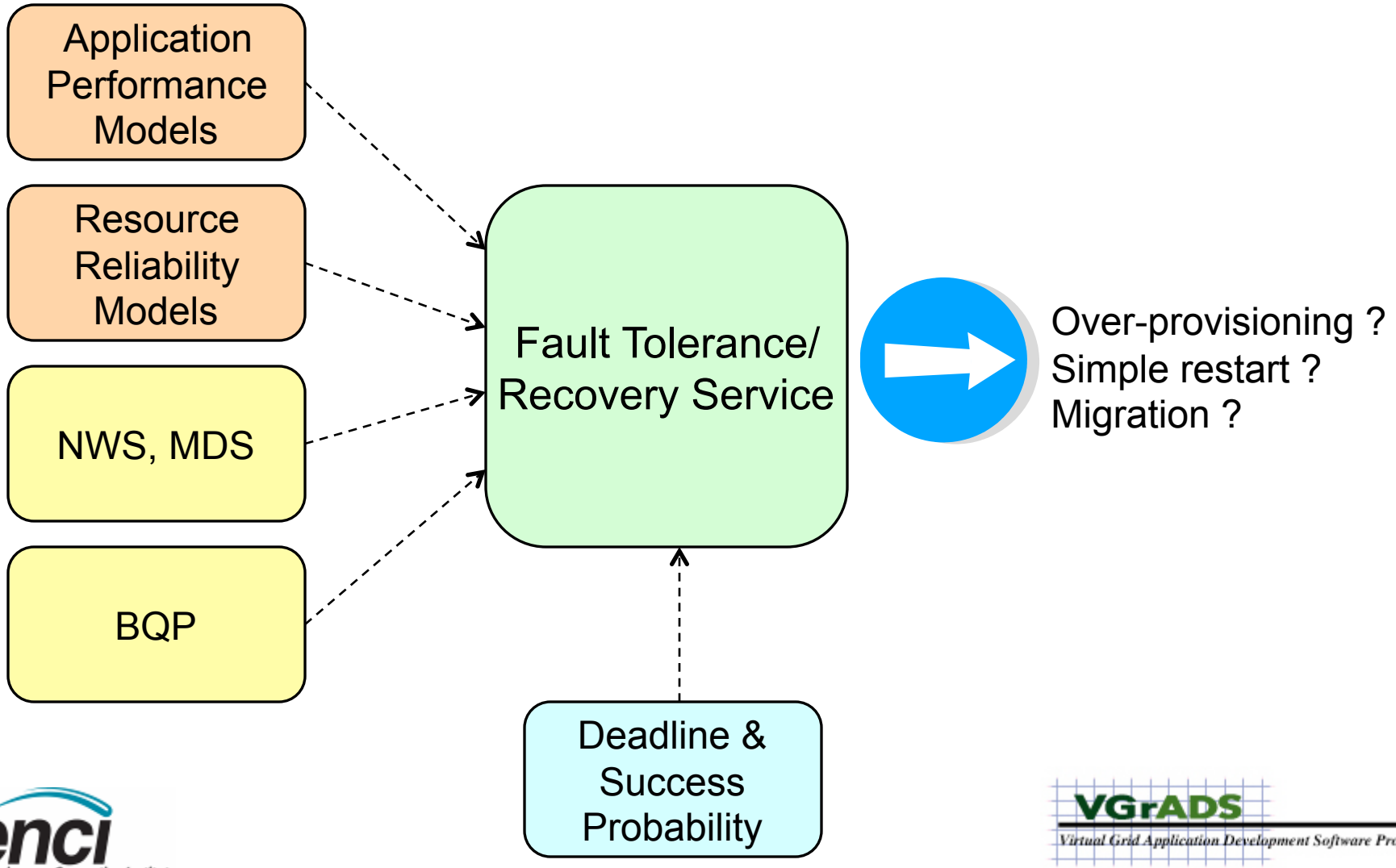
Motivation

- **Reliability and performance are related**
  - **failure is the limiting case of poor performance**
  - **both involve measures of behavior over time**
- **Large, complex workflows are sensitive to failures**
  - **faults are the norm, rather than exceptions**
    - distributed systems, services and resources
  - **completion "guarantees" are problematic**
    - workflow completion is probabilistic in the presence of faults
- **Many time-critical workflows are deadline driven**
  - **severe weather events, disaster response, …**

Fault Tolerance/Recovery (FTR) Service



Simplified Architecture

Portal

BPEL Workflow Engine

Application Performance Models

Resource Reliability Models

NWS, MDS

BQP

Fault Tolerance/ Recovery Service

OVP/ RST/ MIG

Application Service

Notification Service

Deadline & Success Probability

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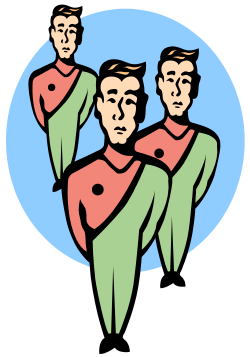
FTR Algorithms

- **Notation**
  - p_i : one hour failure probability of resource *i*
  - h_i : expected execution cost of application on resource *i*
    - queue wait time
    - expected computation time
    - expected communication time
  - *x* : required success probability
  - *d* : required deadline

- **If the reliability function is linear, probability of failure**
  - $m_i = \max(p_i * h_i, 1)$

- **Resource *i* represents (queue, #nodes) combinations**

Over Provisioning



- **Find**
  - **degree and resources for over-provisioning**
- **Number of application copies**
  - **meet a deadline *d* with a success probability *x***
- **Solve the following optimization problem**

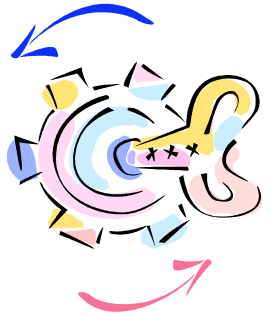
For given *[1..M]* resources, find a partition $P = \{s_1, s_2 \ldots s_n\}$ of *[1..M]* such that

$$1 - m_{s1} * m_{s2} * \ldots m_{sn} \geq x \ \Lambda \ |P| \text{ is minimum } \Lambda \ min\{h_{s1} \ldots h_{sn}\} \leq d$$

Probability of failure

Minimum number of resources meeting deadline

Simple Restart



- Among the current available resources …
  - (universe – faulty resources)
- Find the best resource that
  - meets the deadline and success probability
- Mechanism can also be used for
  - runtime resource selection
- Two FTR mechanisms based on simple restart
  - restart with retries
  - restart if there is no progress

Migration

- **Find the best migration path**
  - **more complex optimization problem**
  - **need to optimize orderings**
- **Solve the following optimization problem**

Find a partition $P = \{s_1, s_2 \ldots s_n\}$ and ordering $\{s_1 > s_2 > \ldots s_n\}$ such that

$\mathbf{1 - m_{s1} * m_{s2} * \ldots m_{sn} \geq x \ \Lambda \ |P| \text{ is minimum } \Lambda \ (t_{s1} + \ldots t_{sn} + q) \leq d,}$

where $t_{si} = (p_{si} * h_{si} > 1)?\ 1/p_{si} : h_{si}$ and q is the migration overhead

Proposed Next Steps

- **Modeling resource reliability**
  - **draw data from job log files in the resources**
  - **maintain constant updates of reliability estimates**
- **Reliability Information Service (viz. BQP)**
  - **"What is the probability that a job, when submitted to a queue at a resource will die before completion because of a failure?"**
- **Balancing multiple mechanisms**
  - **given resource constraints**
    - e.g., over-provisioning and migration
  - **quantifying resource "wastage" with common metric**

Proposed Next Steps (2)

- **Develop runtime rescheduling strategies**
  - **requires following changes in VGrADS software**
    - ability to re-acquire slots
    - ability to relinquish unnecessary slots
    - ability to accommodate FTR directives
    - ability to schedule remaining workflow
  - **requires following change in workflow engine**
    - ability to run a re-scheduled workflow

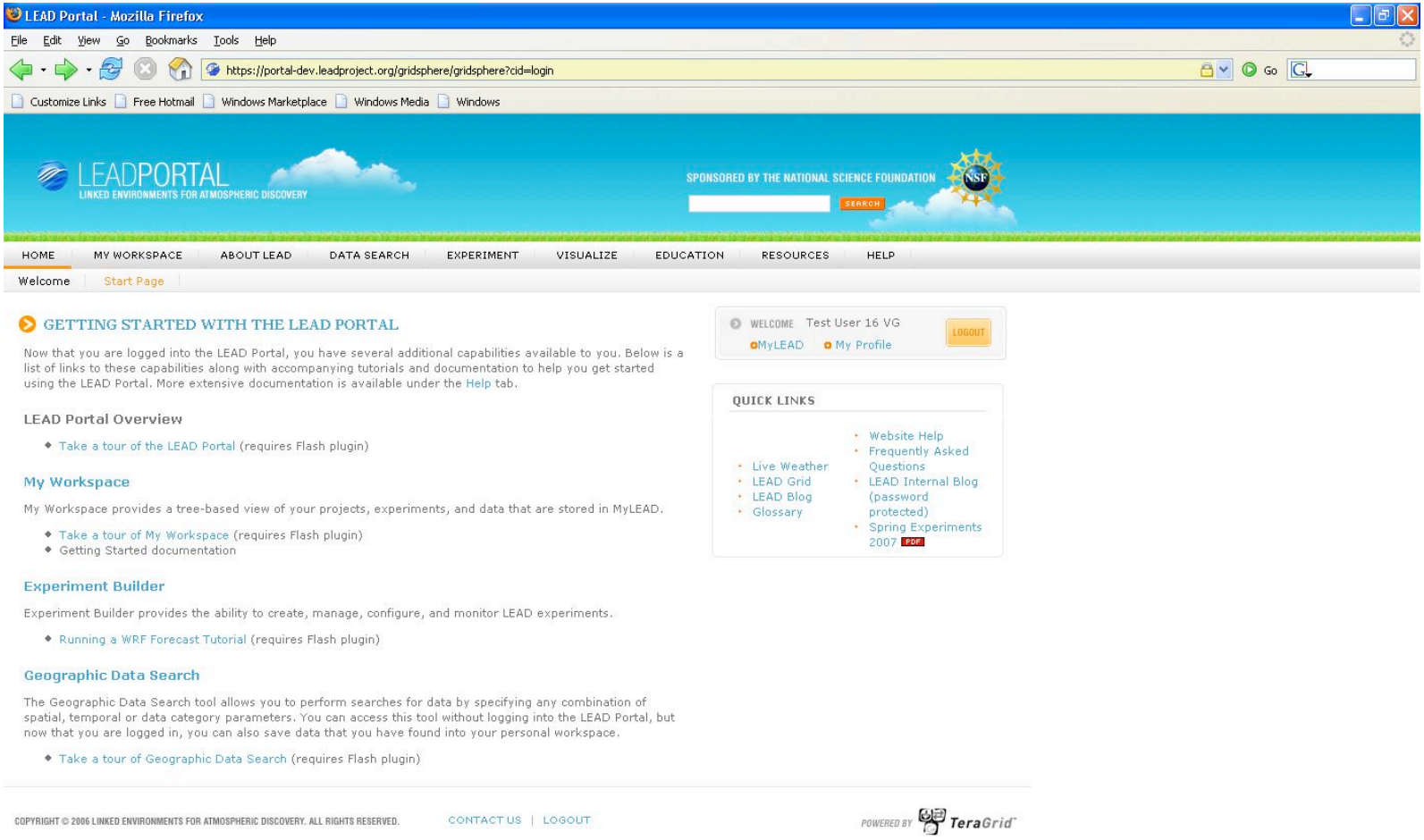
Proposed Next Steps (3)

- **Deadline estimates**
  - **given a deadline for the entire workflow**
    - find deadlines for individual applications
  - **requires critical-path analysis**

FTR Demonstration

- **Launch workflow from the LEAD portal**
  - build new experiment
  - select forecast region and workflow
  - fetch data
- **FTR service manages application execution by**
  - choosing the fault-tolerance mode (OVP, RST)
  - invoking application service(s) as per current mode
  - monitoring for failures
- **Workflow composer shows workflow progress**
  - status of application currently running
  - workflow execution status via notifications etc.

Screenshots



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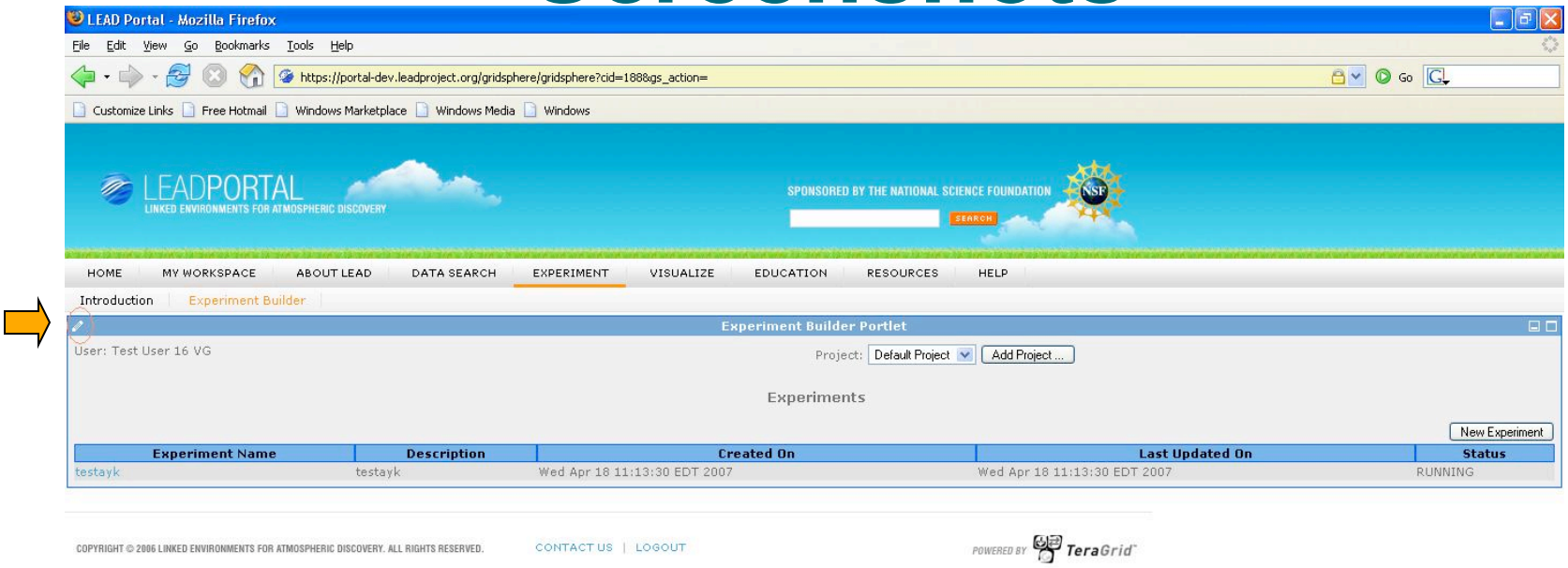

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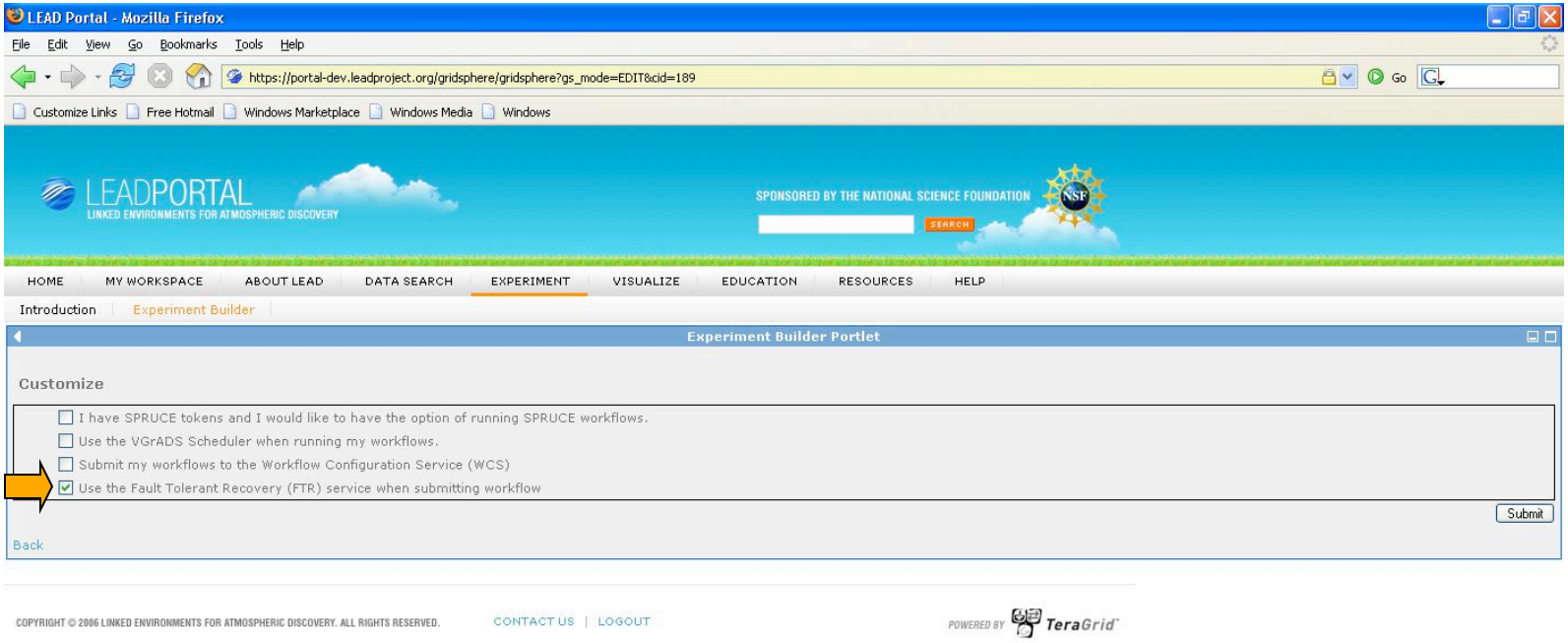

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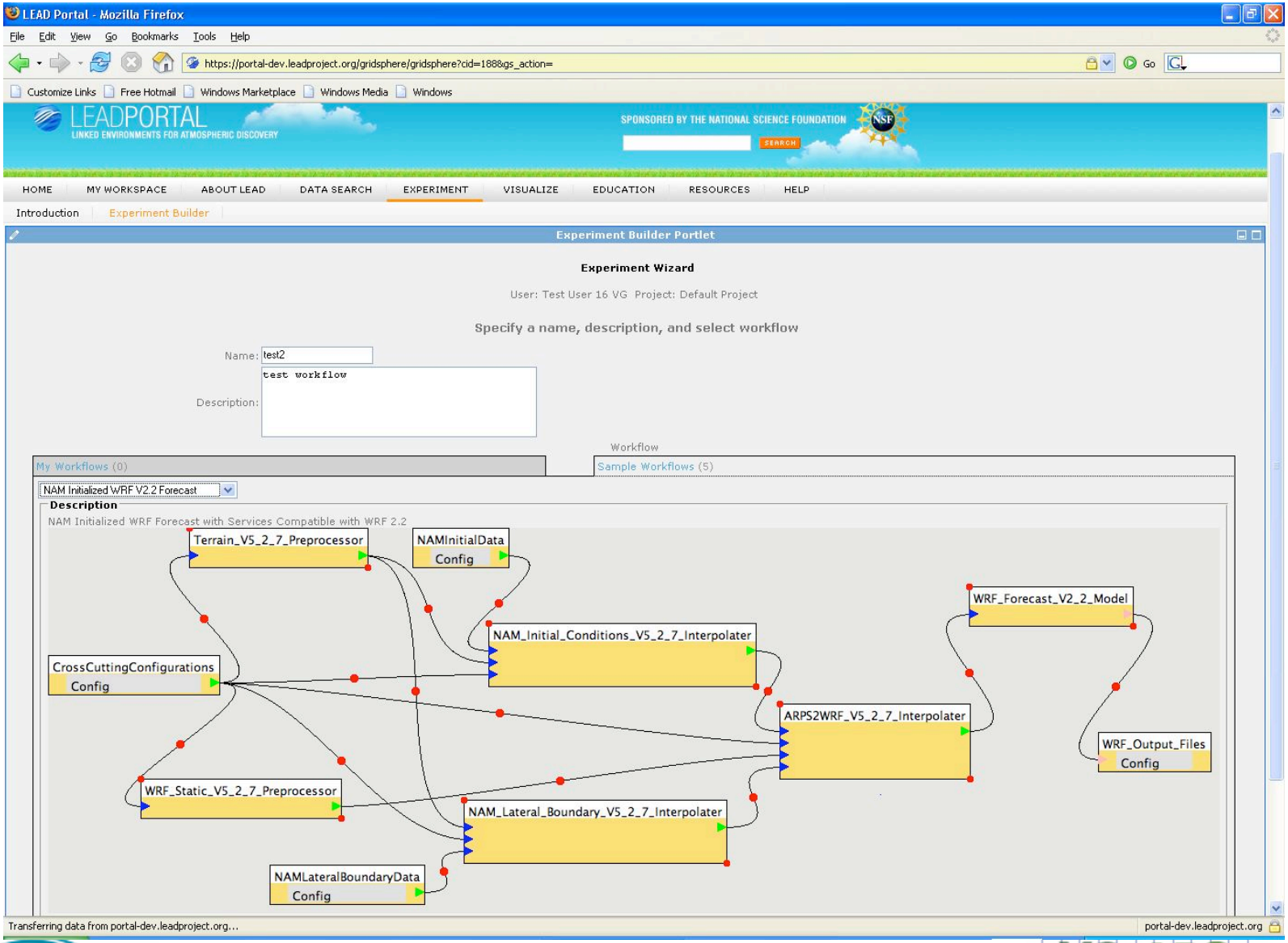

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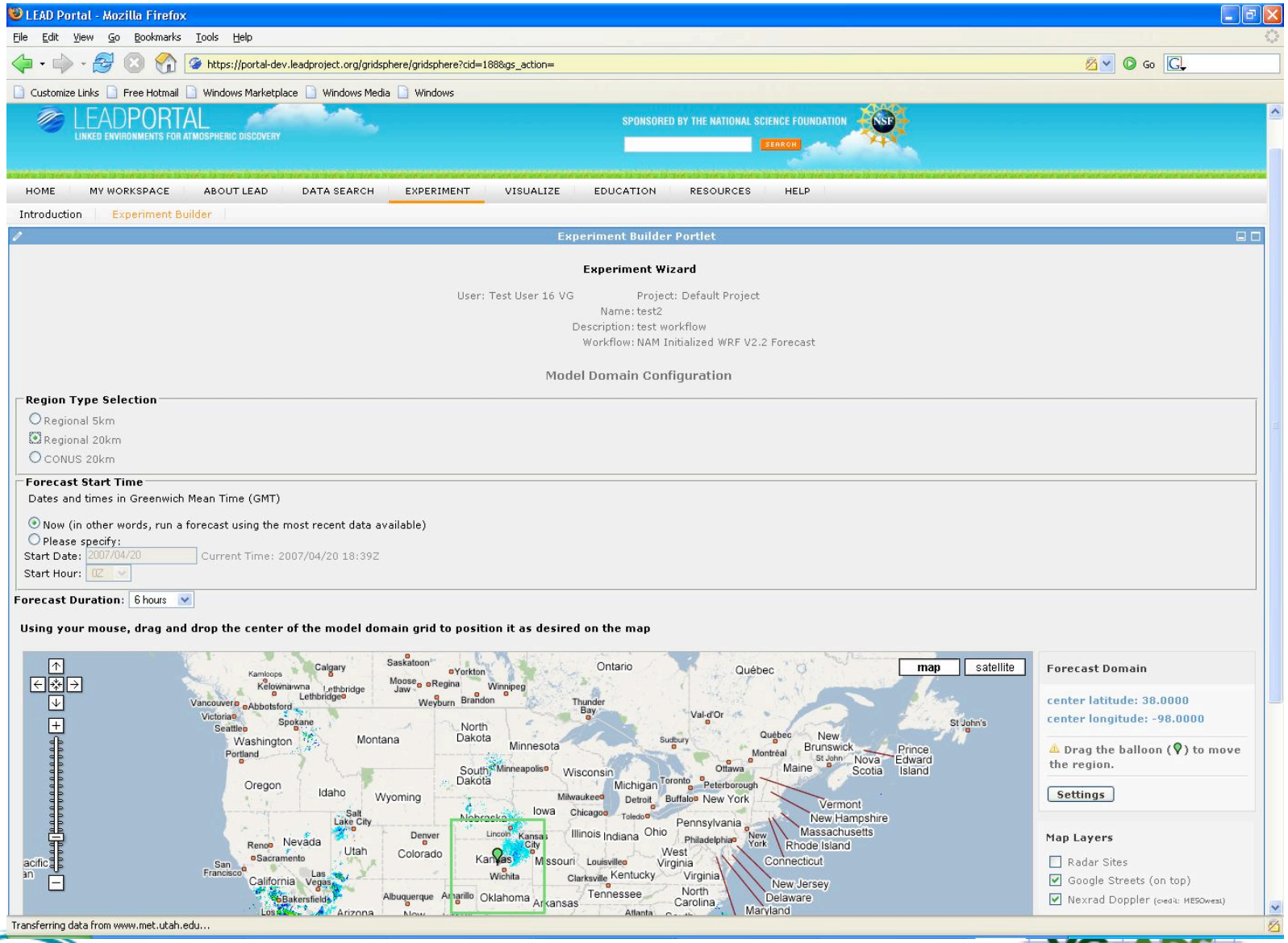

Questions ?