TCIPG

ANNUAL INDUSTRY WORKSHOP
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EARLY EXPERIENCE WITH CLOUD COMPUTING AT ISO NEW ENGLAND

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OUTLINE

- High Performance Computing (HPC) needs in power system analysis
- ISO-NE's cloud computing projects
  - Deploy power system analysis software in the cloud
  - Cloud-hosted wide area monitoring
- Conclusions and near-term plans

HPC NEEDS IN POWER SYSTEM ANALYSIS

- The network size
- The model
  - Non-linear non-convex functions
  - Discrete and integer variables
  - Ill-behaved characteristics
  - Hundreds of thousands of differential and algebraic equations
- The large volume of data
- The complexity of the power grid today and nearest future:
  - Distributed resources
  - Renewable resources
  - High volatility
  - Microgrids
  - Controls
- Simulation is slow and takes long time
- Need high performance computing techniques and advanced computing hardware

TRANSMISSION PLANNING STUDY EXAMPLE

- Southeast Massachusetts and Rhode Island assessment
  - Needs Assessment
    - 36 power flow cases, 295 first level contingencies, 2122 second level contingencies
    - 36 * 295 = 10,620 N-1-1 scenarios; each takes about six minutes
    - 10,620*6 = 63,720 minutes = 1,062 hours
  - Solution Study: at least five different alternatives

- Maine Power Reliability Program (MPRP) stability study
  - 11 power flow cases, 477 dynamic contingencies
  - One twenty-second dynamic simulation takes about 15 minutes in PSS/E
  - 11*477*15 = 78,705 minutes = 1,312 hours

ISO-NE'S CLOUD COPUTING PROJECT

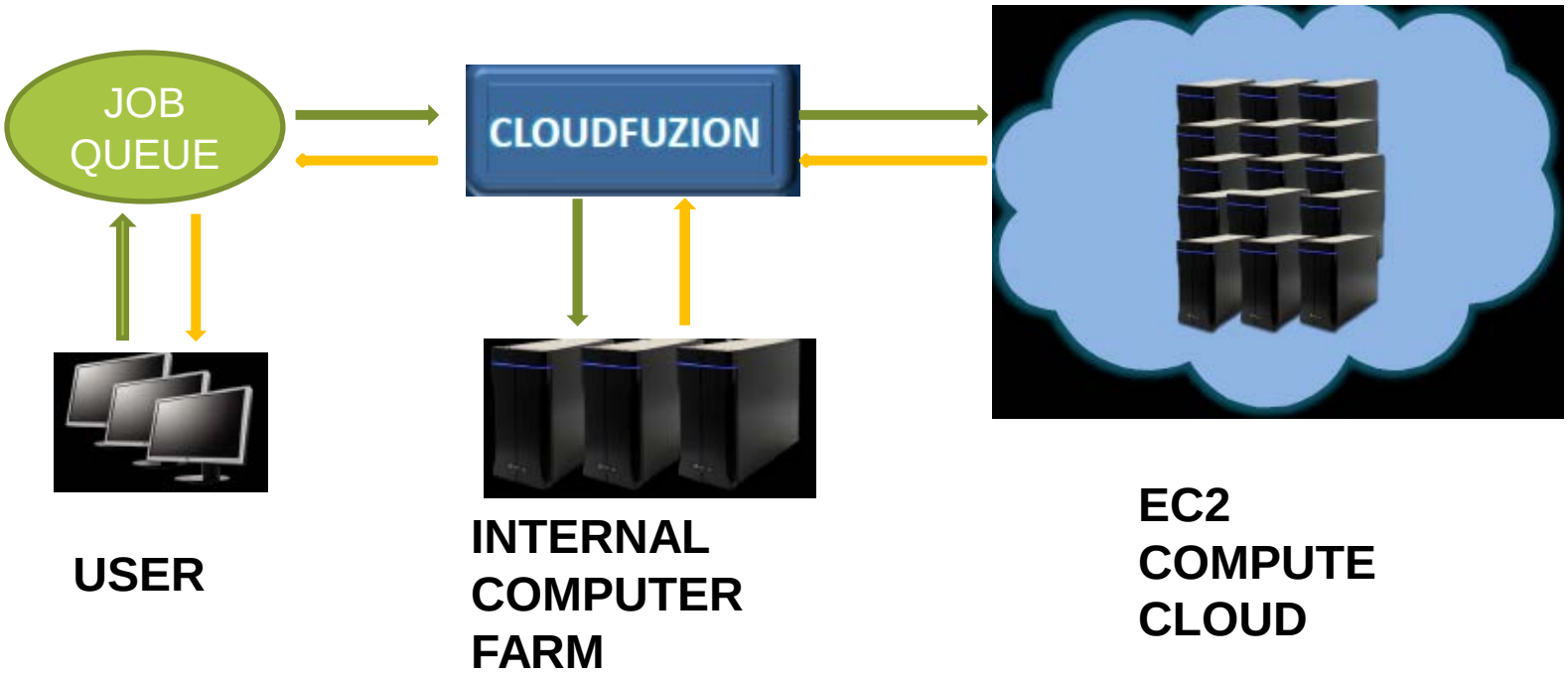
- On-premise EnFuzion based grid computing environment
  - Huge resource constraints and long waiting time in queue
  - Engineers have to limit the number of jobs or perform model reduction to save computing time
  - Maintenance: hardware failures and constant patches by IT
  - Hard to estimate the peak demand and average business computing needs and purchase the IT infrastructure accordingly
- Objectives of the proof-of-concept cloud computing project
  - Get hands-on experience and knowledge of the cloud computing technology
  - Experiment deploying power system applications in the cloud environment
  - Benchmark performance between cloud run and internal run
  - Estimate cloud infrastructure usage cost
- A special cloud license scheme was developed for TARA used for N-1-1 contingency analysis

ISO-NE'S INFORMATION POLICY AND CEII

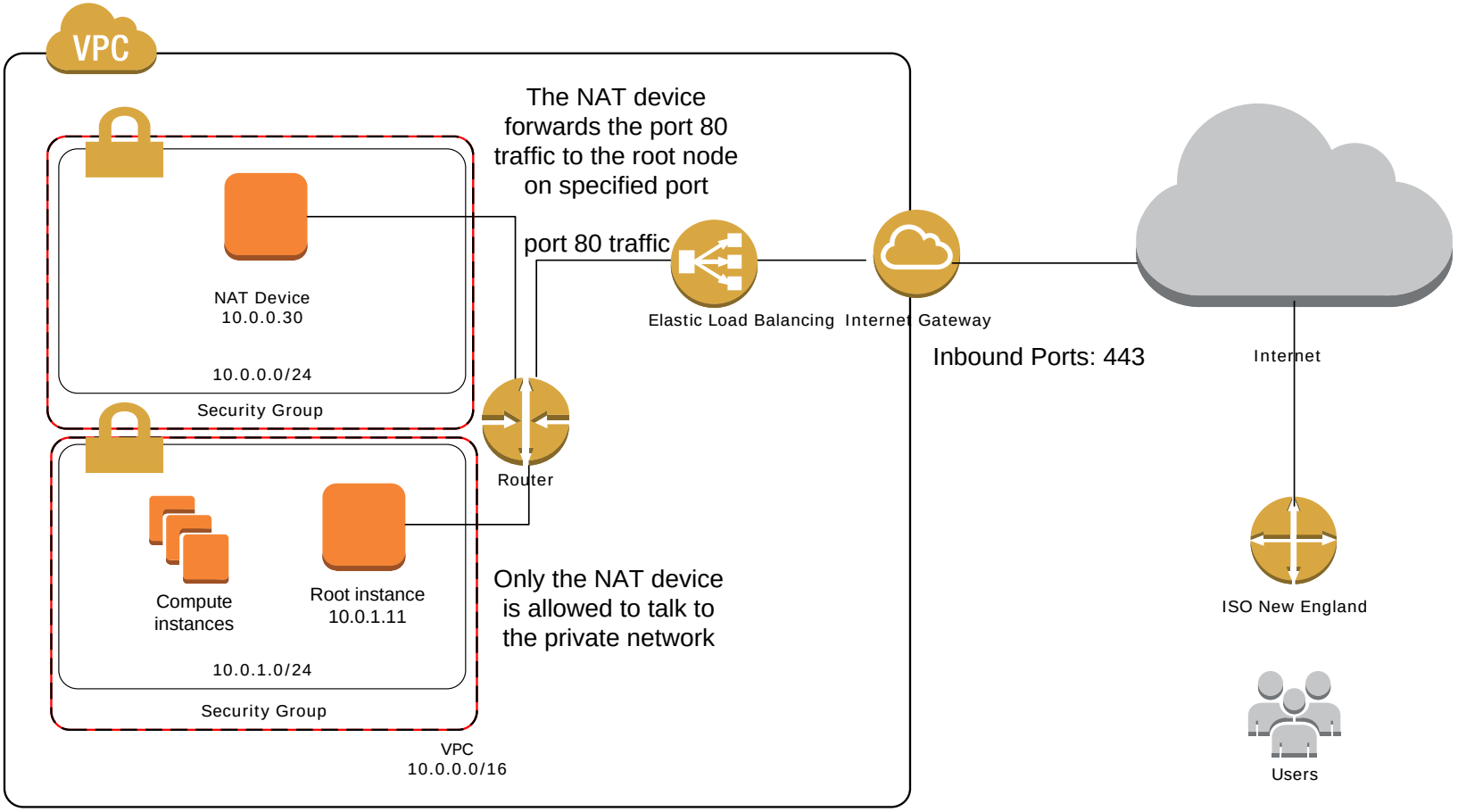
- ISO Information Policy
  - Establish rules and guidelines regarding the appropriate disclosure of all information received, crated and distributed in connection with the operation of and participation in the markets administrated by ISO-NE
- Critical Energy Infrastructure Information (CEII)
- ISO-NE policy establishes two thresholds for CEII identification:
  - Bulk Electric System asset information that relates to proposed or existing generation assets greater than 5 MW
  - Proposed or existing transmission asset rated at 100 kV and Above
- Criteria used to determine if information is CEII:
  - The information may be in the form of a diagram, map, drawing, or raw data such as power flow model data or results
  - The information may also be in written format in a sentence, paragraph, report, or slide presentation
  - Information already marked as ISO New England Critical Cyber Asset information is automatically considered CEII

CLOUDFUZION – CLOUD JOB SCHEDULER

- Robust workload management (e.g., automatic rescheduling of failed jobs)
- Support major 64/32-bit hardware platforms and all major OS platforms, including Windows, Linux, etc.
- User-friendly web interface for submitting, monitoring, and managing jobs
- Hybrid - bridge internal resources with external clouds
- Minimum changes to existing script files used for internal cluster



IMPLEMENTED CLOUD ARCHITECTURE



SECURITY SCHEMES

- Identity and Access Management (IAM)
  - Create and manage users and groups
  - Assign individual security credentials (e.g., access keys, passwords)
  - Use policy to control each user's permissions to perform tasks using AWS resources

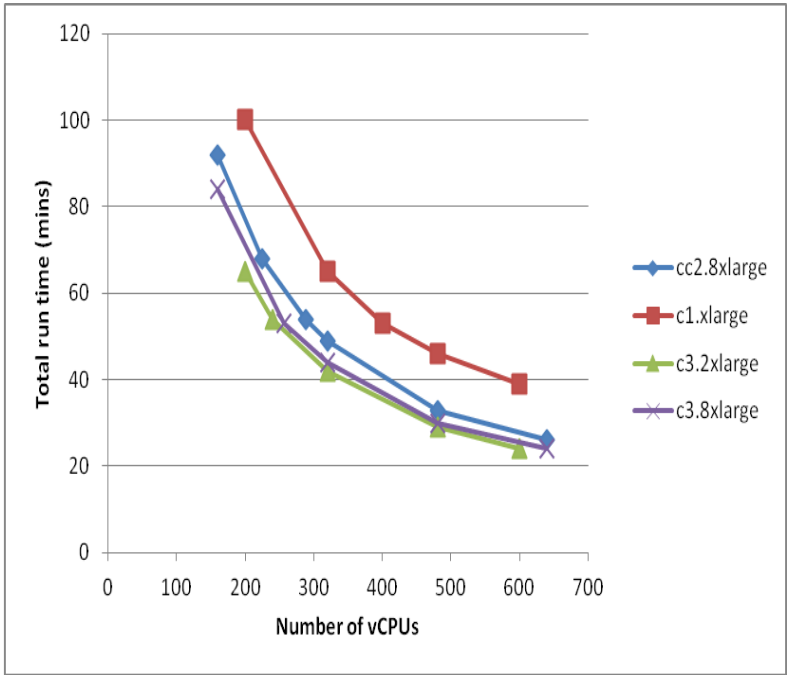
- Virtual Private Cloud (VPC) deployment
  - Logically isolated section of AWS under users' complete control
  - Option to allow running instances on single-tenant hardware
  - Root and compute instances are located within a private subnet of VPC, and none of them carries public IP addresses
  - Only the NAT instance is allowed to communicate with root instance
  - Any attempts to access the subnet from outside to VPC are completely blocked.

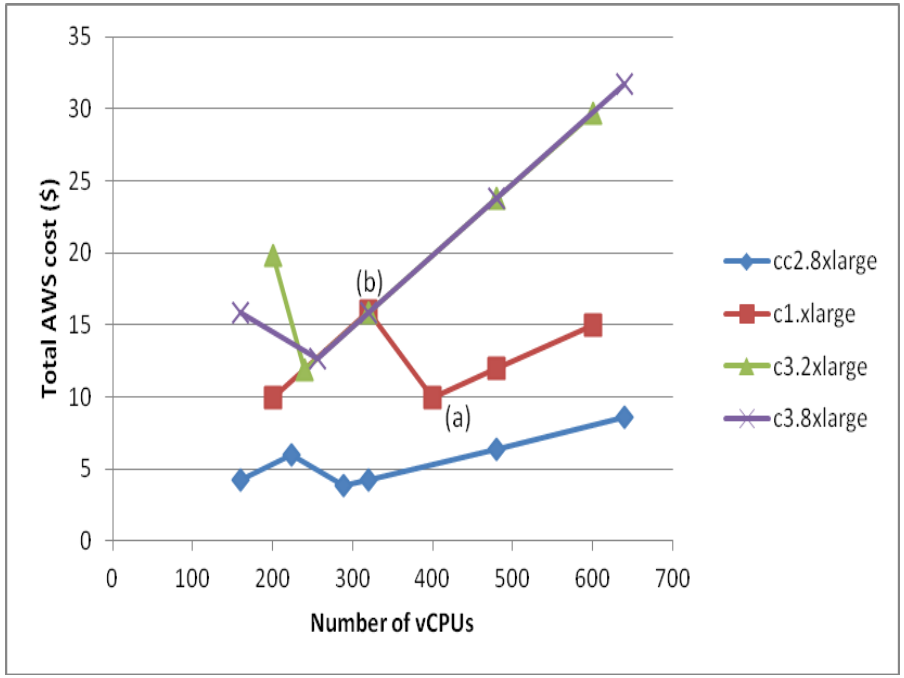
SECURITY SCHEMES (CONT'D)

- Security group control
  - Virtual firewall controlling the traffic for EC2 instances
  - A specific Security Group is created and linked to Elastic Load Balancer (ELB)
  - Specify the allowable inbound and outbound traffics (e.g., source IP address, protocol, port)
- Secure data transmission
  - SSL certificates are created for data encryption using HTTPS protocol
  - The Elastic Load Balancer (ELB) uses the certificate to terminate the SSL traffic, decrypt and forward the request to NAT instance
  - NAT instance uses an IP table rule to direct the traffic further to root instance
- TARA Application
  - life cycle of license file

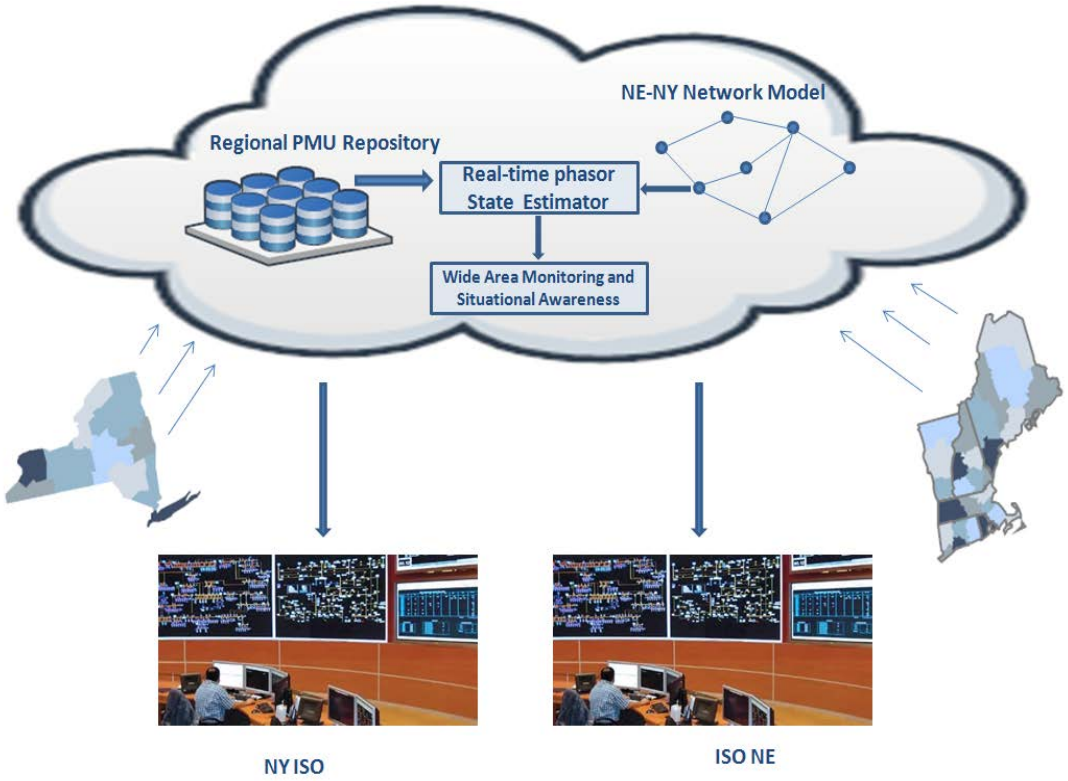
CASE STUDY

- 7,090 TARA N-1-1 simulations in Greater Boston Reliability Study
- 470 hours on engineer's desktop and 8 hours in internal clusters
- Nine CC2.8xlarge instances (32 cores/instance @ 2.60 GHz, 60.5 GB memory); finished in less than one hour and cost about $5.00.





CLOUD-HOSTED WIDE AREA MONITORING



Benefits:

- Supplemental and backup to the traditional SE
- A new platform for collaborations between control areas
- Explore all benefits and concerns of the cloud computing and advance the technology in the power industry
- A new and efficient way for synchrophasor data exchange and repository, further advance the synchrophasor technology

CONCLUSIONS AND NEAR-TERM PLAN

- Still at early stage of cloud computing technology
  - The beta production cloud platform is ready to be released to planning engineers for TARA N-1-1 study
  - Expand the user base to operations support engineers
  - Additional cloud deployment of PSS/E and TSAT
- Cloud-hosted wide area monitoring
  - Project team: ISO-NE/NYISO/NYPA/Cornell/WSU
  - Simulated PMU vs. historical PMU vs. real-time PMU
  - Other PMU applications such as Measured based Voltage Stability Assessment (MBVSA)

- Security concerns shall not discourage adopting cloud computing; it is necessary to understand responsibilities and adapt security practices to this new environment
- Continuous development of Internal IT cloud policy