GridStat Middleware Communication Framework: Systematic Adaptation

Overview and Problem Statement

GridStat is a middleware communication framework with ultra-low latencies and high availability that is aimed at providing wide-area data delivery capabilities for the power grid. GridStat's data plane is a tightly managed mesh overlay network that provides stringent, rate-based delivery guarantees. However, the data plane components are susceptible to arbitrary (Byzantine) failures and cyber-attacks that, if not addressed, have the potential to make those guarantees unachievable. Furthermore, even non-malicious changes within the operating environment—for example, a sudden burst of large subscription requests triggered by a power contingency or benign component failures—may also force reconfiguration in order to meet the guarantees, particularly for the most important applications, given the present power and cyber conditions.

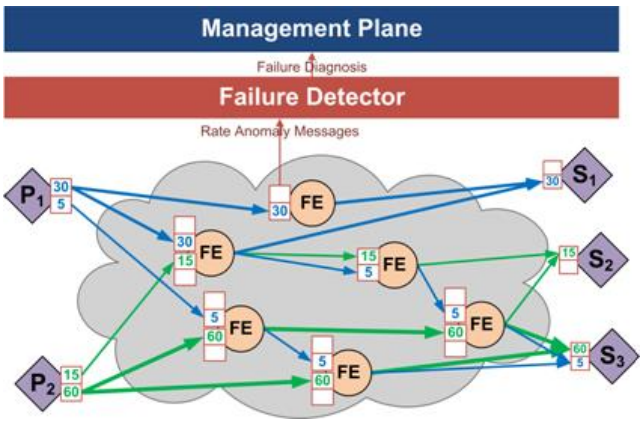
The objective of this research activity is to develop adaptation services and supporting instrumentation services for GridStat in order to systematically adapt to changing conditions and available resources. Those adaptations must be performed such that the strongest possible delivery guarantees (latency, rate, number of paths) are provided to the most critical applications, yet other applications are given guarantees commensurate with their present criticality, rather than being starved of resources. The adaptations also must strike a principled balance between over-adapting, which could be exploited by adversaries, and under-adapting, which, for example, would allow highly critical sensor inputs to a closed-loop control or regional protection scheme to have less resiliency (number of paths) than is acceptable.

Research Objectives

- Design and develop a minimally intrusive yet pervasive instrumentation service to monitor the data plane.
- Design and develop a failure detection service appropriate for mission-critical, rate-based sensor traffic.
- Identify the most important perturbations that can affect GridStat's delivery guarantees.
- Develop an adaptation framework for GridStat that reconfigures all affected sensor delivery flows in a systematic fashion, providing delivery guarantee strength commensurate with the criticality of the applications subscribing to those sensor flows.
- **Smart Grid Application Area:** Wide-area monitoring and control.

Technical Description and Solution Approach

- Model and assess the performance characteristics of GridStat under various constraints that affect normal functionality. Activities will broadly fall under simulation-based assessments and use-case-based assessments.
- Determine the required level of instrumentation that maximizes adaptation-related evidence-gathering with minimum effects on data delivery performance.
- Survey and research existing Security Information Event Management (SIEM) and Complex Event Processing (CEP) techniques to discover analogous compound adaptation triggers based on multiple kinds of instrumentation inputs.
- Implement an adaptation service for GridStat that is highly tailorable both in the steady state and under changing conditions.



- Explore the use of utility functions in order to optimize the benefit of the data delivery service over an entire grid, given the present power and IT conditions.

- Explore the use of pre-computed information on failures (links, forwarding engines, etc.) and their effects. Such pre-computations exploit the (quantitative and qualitative) knowledge GridStat must maintain at every location in the delivery network to provide mission-critical delivery guarantees and respond to failures rapidly.

Results and Benefits

- The ability of GridStat to rapidly and accurately detect a wide range of anomalies and adapt in a way that makes the power grid and other critical infrastructures as resilient as possible.
- The ability of GridStat to incorporate a wide range of instrumentation feeds and adaptation strategies that utilize them.
- Partnerships and External Interactions: North American Synchrophasor Initiative (NASPI).
- **Technology Readiness Level:** This research is still at the early stages of development, but the core contribution, once completed and incorporated with the main GridStat software, is expected to be a core GridStat functionality.

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