Command & Control Environment Timeliness Characterization

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Abstract

The objective of this work is to characterize a method for providing timeliness quality to the distributed collaboration environment. Timeliness is an important principle in the coherence of data within a given flow. This flow in turn has a direct bearing on the consistency of a given situation perception. Resource management within a given system, residing on a distributed command and control environment, is a critical element of maintaining a timely flow of cognitive data. Yet this critical element has been given minimal attention at best, during the development of command and control systems. This paper will present a current approach for the management of resources within this environment.

Introduction

The military distributed command and control environment is a demanding framework necessitating and requiring transformation as rapidly as the pace with which our contemporary technology advances. [Harn, 1999] The requirements of command and control systems are extremely unstable and changeable due to tactical surprises, changes in goals and missions, etc. Currently, an ever increasing level of distributed programs require conventional end-to-end service guarantees. [Flores, 1999] Next-generation distributed real-time applications, such as teleconferencing, avionics mission computing, and process control, require endsystems that can

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provide statistical and deterministic quality of service (QoS) guarantees for latency, bandwidth, and reliability. Programs, which require consistent situation perception for collaborative planning, and decision making fit into this taxonomy. These guarantees include elements of bandwidth level requirements, selectable levels of reliability, adjustable jitter, and controlled variable latency levels. The timeliness of a given data flow and the end-to-end service provisions mentioned above are be based upon the resource management on the systems along this flow path. Quality of service contains many elements of which interaction is an important constituent as illustrated in figure 1 below [Lounsbury, *et al.*, 99].

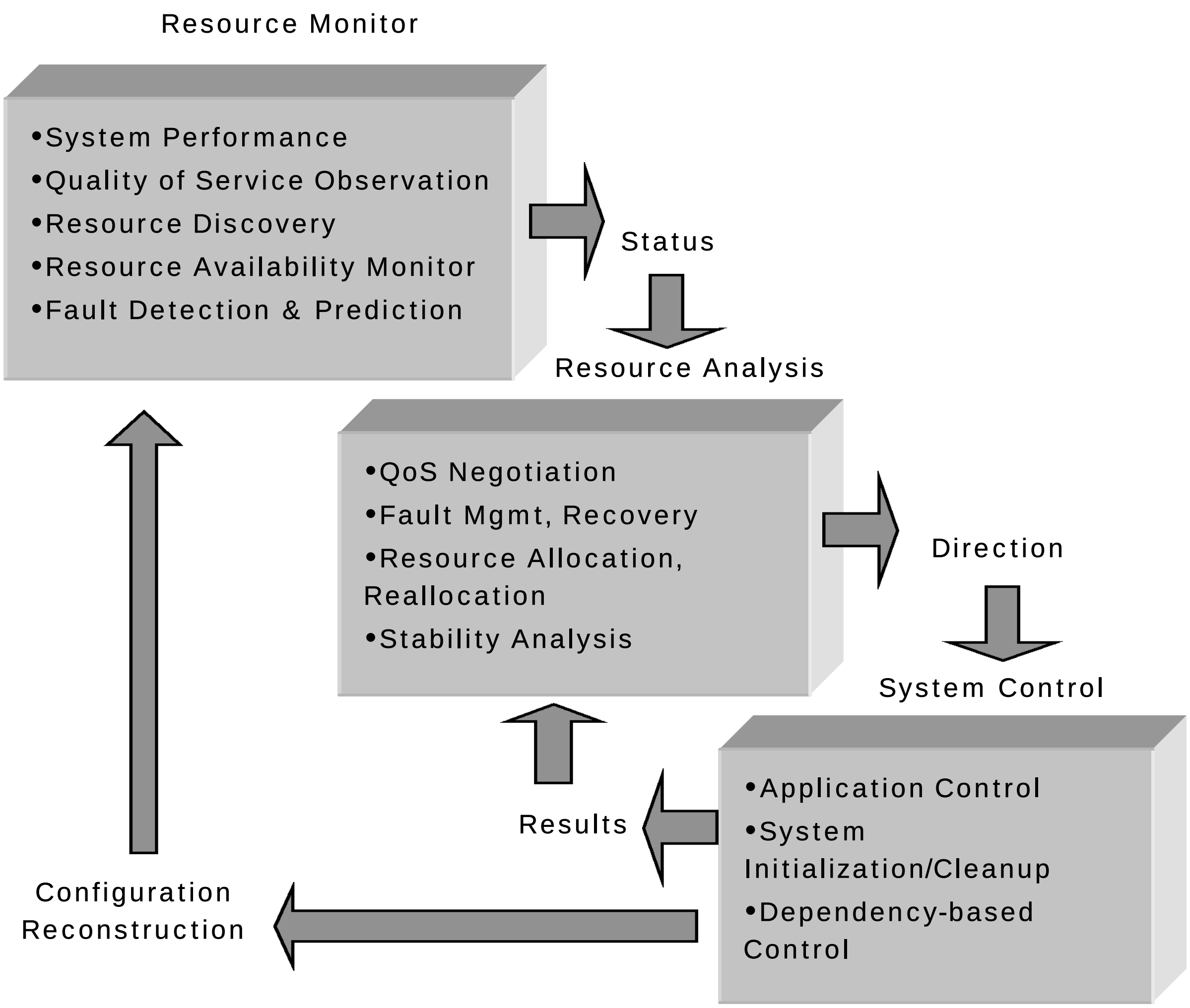

Figure 1. Resource Management

Current work in this area is focused primarily upon the implementation of the end-to-end timeliness service, however the resource management of this service is the paramount issue. [Roch 1998] Technology currently exists for quality of service, and at a reasonable resource cost, however there is a highly variable costing structure with bulk of the overhead is in management of

QoS, not just making it available. Other current work focuses upon management of the path itself. [Xie, 1998] We need a Path Information Base to provide info on available paths, and to be able to put it in a separate server rather than adding it to the list of things that routers have to do (they're already busy enough). This will allow for the organization of a hierarchical pathway structure, but we still need management of resource utilization at the individual system level to complete the end-to-end cycle.

Resource management is a major element within the realm of the quality of service notion. This resource management can include many domains as illustrated in Figure 2 below [Lounsbury, *et al.*, 99].

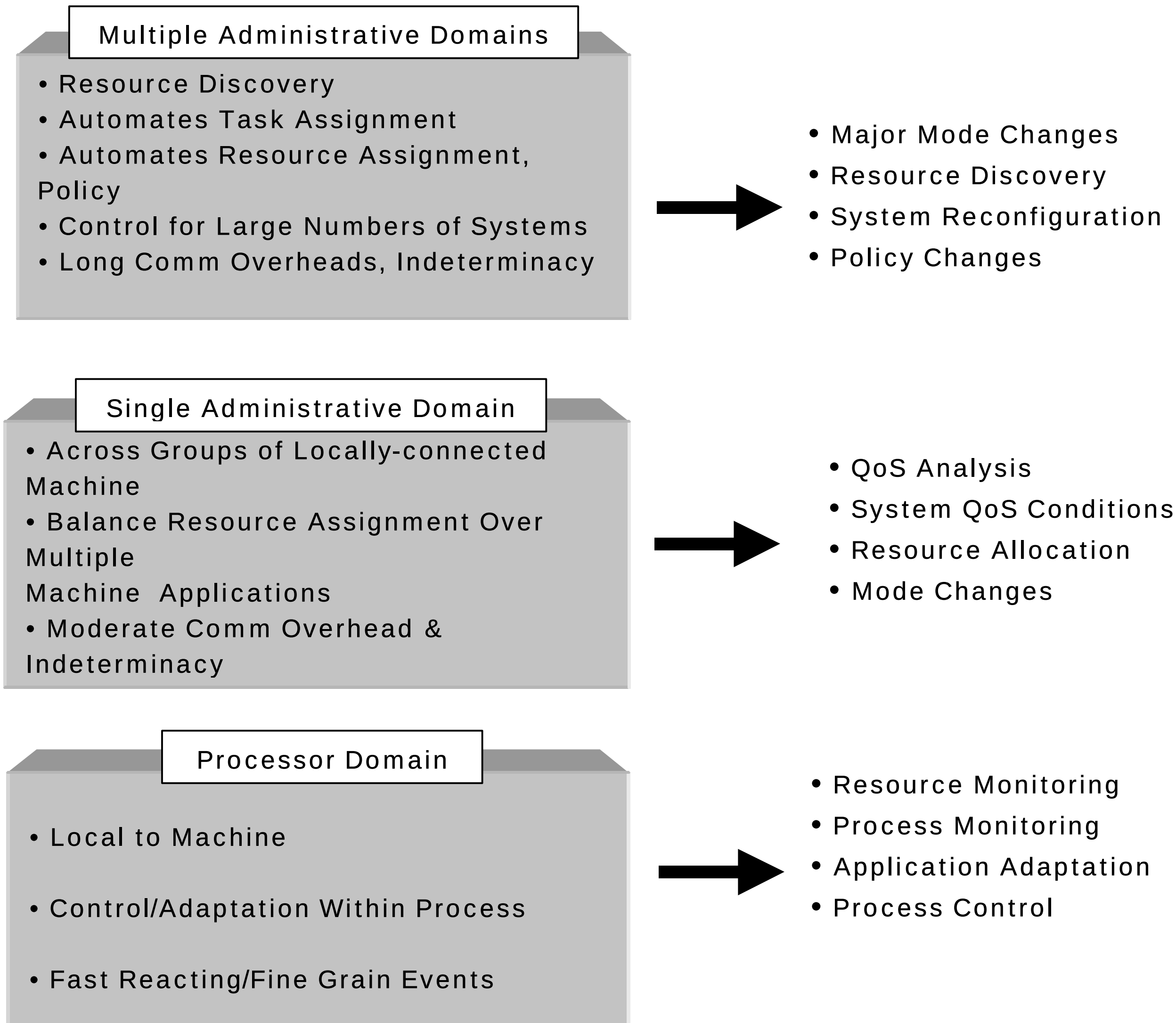

Figure 2. Resource Management Scope

Approach

The utilization of a resource management approach to isolating timeliness elements necessitates a significant understanding of the characteristics of time accentuated segments of command and control systems. One method of attaining a greater degree of understanding of the command and control environment is to develop a model of the system. The work undertaken by desiderata [Welch, *et al*,. 97]. suggests that this model be one of three environment types: Deterministic, Stochastic, or Dynamic. “A deterministic environment exhibits behavior that can be characterized by a constant value. A stochastic environment behaves in a manner that can be characterized by statistical distribution. A dynamic environment depends on conditions which cannot be known in advance” [Welch, *et al*,. 98].

The focus upon the isolated path information base is pursued under this approach. There are specific timeliness elements associated with the data streams in path based system models which includes situation assessment, initiation and guidance. This approach utilizes an adaptive resource management architecture based upon three situations: initial startup, missed deadline, and program termination fault. A sophisticated specification language called D-SPEC has been developed [Welch98] which provides a method of characterizing a specific systems in a deterministic, stochastic, or dynamic behavior.

The approach to this work is based upon the presumption that systems within a distributed end-to-end command and control path must support resource management within a specific timeliness parameter to achieve proper situation assessment. Without this support the possibility exists for a given situation to be perceived through the utilization of late or out-of-order input data. A resulting false situation assessment could then lead to a flawed or faulty decision being pursued. This characterization work therefore has begun through an investigation of how a specific system can mitigate resource utilization timeliness requirements within end-to-end quality of service environments.

Conclusion

This work provides an excellent approach for applying formalism to the Command & Control environment and performing direct analysis of timeliness characteristics. This investigation is accomplished by an in-depth look at various systems through kernel and middleware level examinations. The inquiry of these layers is achieved through the utilization of the SPAWAR System Center DARPA Quorum Integration project testbed as well as other DARPA Quorum research. Detailed timeliness analysis is focused on the elements of bandwidth levels, levels of reliability, jitter, and controlled variable latency levels. Specific command and control data (typical of normal operating environments) is then input into the testbed control systems, the system timing data is measured, recorded and carefully assessed based upon correctly perceived situations. This is accomplished through the utilization of simulated elements typically found within command and control environments. One of these elements, the simulated sensor, reads input from a previously generated scenario file and subsequently provides a set of track data which are in turn based on motion equations. The track data samples represent the current position of the moving entity being observed over time. Action can be taken which is based upon information sent to evaluate & decide data managers. Thorough the use of this simulation timing data is generated and can be observed.

This analysis shows that resource management has a direct bearing upon timeliness within a command and control environment. When controlled through the specific application of previously developed path models and resource isolation using specification languages certain timeliness element can be segregated and applied to typical command and control environments. Future work in this area will examine the specific application of more detailed formal proofs to this environment.

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