Context-based Information Sharing and Authorization in Mobile Ad Hoc Networks Incorporating QoS Constraints

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1. Introduction

When one thinks of today's command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4IS) network, it usually evokes images of multiple operators in command at the same time for a collaborative mission under environmental and operational constraints. Some of the steps occur before the F/A-22 detects the target. Application programmers and end users contact the discovery service and search for services that produce the information they need. With the network-centric technology having increased adoption, operators need to coordinate and understand the given situation for replanning and rescheduling multi-objective decision making. Therefore, they must correlate and integrate many geospatial and temporal features along with the environmental constraints. The peers in the battlespace must be able to take multi-objective decisions to operate efficiently while satisfying multiple operational, but conflicting constraints like optimal route planning, response time, computational cost, communication bandwidth in a distributed network. The proposed framework provides a mechanism to bridge the gap between computation resources and dispersed data sources under operational constraints such as bandwidth and environmental constraint such as weather. For every computation task raised (i.e., a service request), a viable system that has information about the optimal cost route, resources and data availability to compute the task is identified and the task is sent to the viable system for completion using the optimal path to satisfy QoS constraint. Given the mission task, the system will also have the ability to predict future data needs, route and prepare resource allocation plan for those needs.

Context-based authorization is needed in C4IS environment where due to security and privacy reasons peers do not want reveal their identities, or share secret keys. For example, some fighters (JSF, F-22) do not want to transmit their identities and secure keys etc because they don't want to be detected. Similarly, a UAV (Unmanned Aerial Vehicle) may be looking for some content based on the current situation from another UAV in the vicinity or soldiers on the ground are looking for some services, but they would like to discover them without revealing their identities or sharing keys for data authorization due to security restrictions or communication timeout. Even though both the user and service providing peers are legitimate users, neither of them wants to reveal their details first before the other does, thus can cause a deadlock situation, similar to a chicken-and-egg problem. In addition, some peers may be only entitled to situational-aware and context-based information dissemination based on his role though these peers may have been authenticated by the network, but not all the peers are authorized to take/provide a particular service. For example, a coalition force node may be authorized into the network, but only allowed some limited access to only some information which may not have all the details. Thus, a peer should authorize each other only if that service can be provided by the peer who is authenticating. The solution also requires validating each others' authentication as a two way process rather than one usual one way authentication only (independent of content) and authorization (based on the content entitled to). Moreover, since many peers may be moving sometimes at a higher speed and therefore, the connection available may be very fragile because existing data links don't have large bandwidth to share and can cause a denial of service. Thus, a solution has to have state remembrance/checkpoints so that the process does not need to restart again and again. Therefore, some privacy-preserving techniques with stored states can be used to establish the content authorization.

We propose to provide a tool which can be integrated with for aided task planning, incorporating spatial and temporal constraints, device and network conditions, and dynamically changing intelligence information. The peers will be responsible for very large areas, and may be relying on each other for multi-objective decision making and data requirements. To maintain overall C4IS in this complex, fast, dynamic environment, and computer aided analysis and automated generation of relevant overlays is absolutely crucial.

The network is highly heterogeneous with numerous actors with their individual and collective tasks. These actors may also include manned and unmanned ground vehicles, networked soldiers and weapon systems supported by different shipborne, airborne and spaceborne civilian and military assets. Each of these actors is a source of information as well as user of the information in a networked battlefield. This explosion of information provides an opportunity to gain tactical advantage over the adversary but also poses a challenge. The challenge is to sift through this information and identify mission critical information to help plan or re-plan the mission. The challenge is to research and develop a decision-aiding mechanism for using new information sources to provide dynamic resource allocation, optimal route to source data, planning and re-planning (due to change in tactical scenarios) assistance to human operators in the battlefield guaranteeing QoS.

Research Objectives:

- To conduct research towards and evaluate feasibility of a C4IS decision support tool that integrates networked intelligence information to support the UAV’s data analysis, computing and networking constraints and decision-making process for dynamic route planning and mission execution in an environment with spatially and temporally dispersed and constrained resources. The high-level functionality collaborates with the human user to increase the analysis quality and off-loads lower functions that can be performed by a computer.
- The proposed system is network centric and is expected to operate in real-time. When given the mission intent, the system will be able to provide dynamic guidance, data, computing capabilities, for interactive analysis and mission planning. Also, the system will track the progress as the mission unfolds, by taking into account changes in the battlespace as they occur. Critical changes in the battlespace with potential to affect advance or change in mission will be indicated to the operator. The system will also have the ability to initiate automatic resource allocation and deallocation of data, computing, re-planning where possible. The same concept can be used in actual battlefield for guidance and planning as well as for more effective instructional feedback and training in battlespace analysis.
- In the battlespace context, there are three distinct dimensions of an operational tactical mission: conceptual, spatial and temporal. The conceptual part of the mission addresses the issue of intent and purpose of the mission and includes overall goals, individual responsibilities and the sequencing of tasks and events. At the conceptual level the mission

must conform to the correct protocols and rules of engagements. The spatial dimension of the mission plan seeks to execute the mission intent geospatially under the constraints imposed by the current terrain and any available spatially relevant intelligence information. Temporal dimension of the mission would seek to ensure desired evolution of the mission in time, while accounting for difference in spatiotemporal mobility of different actors and the dynamic nature of the battlespace.