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Title: **Managing Areas of Interest in Command and Control Information Systems**

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# Managing Areas of Interest
# in Command and Control Information Systems

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## Abstract

The global information Grid (GIG) [8], i.e. the connection of all (military) systems from sensors to actors, forms the technical basis for realizing the power of the network-centric warfare concept [1], [11], [17]. In the GIG potentially all the available data about own and enemy troops as well as other information becomes available. To handle the problem of information overload we have to restrict the (visualized) data in an operational picture to only that information that is relevant for the user [6], [7], [9], [14]. A command and control information system (C2IS) therefore has to provide corresponding filtering mechanisms.

Areas of interest are one such concept. Here the user can define an area like the surrounding of his own position where he wants to get informed about other objects that are within that specific area. This is feasible since most of the data presented in a common operational picture (COP) by a C2IS have some spatial reference. This includes positions of blue forces, spatial data like information about streets or bridges, and others.

Starting from the idea of a proximity service [10] that delivers all objects within a certain proximity of another object we can extend a simple rectangular or circular surrounding by more complex shapes [13]. Relevant areas of interest can be based on two observations: First their potential impact on ourselves at our current position and second their potential impact in the future.

For the first observation we can use object properties like their speed or the range of their weapons to determine a distance from within they can be a potential threat (in case of red forces) or supporter (in case of blue forces). Mobilized artillery units, for instance, have a much wider range than a non-motorized sniper in an urban environment. These object-specific distances can than be used as a basis to define our area of interest.

For the second observation we can use machine-readable information about plans and orders to predict our own (planned) positions in the future as well as those of other forces. A patrol or helicopter crew can thus include blue forces and potential enemy threads along their (planned) route into their operational picture. Here the user may be interested in the current objects along his route or in the predicted objects there or in both.

Such user-parameterized areas of interest thus define a set of objects that the user is interested in. This implies that his COP-service can subscribe to those objects to get informed about changes of these objects. However, before our COP-service can do this, we first have to find out which objects are actually within our area of interest. Let *N* be the total number of objects

available within the GIG, this requires *O(N)* time, since we have to check the position of all *N* objects. Unfortunately, we are not the only user but according to the NCW approach in principle all blue forces can in principle do the same. This implies that all objects may define their own local areas of interest for which they have to check the positions of all other objects in turn. Implemented naively, this would lead to an algorithm of complexity $O(N^2)$, while synchronized all-to-all algorithms can do this in $O(N \log N)$ time [3]. This is, however, still not satisfactory. The reason is that – while there are only a few objects relevant for our area of interest (their number being in general much less than *N*) – we filter out objects according their position from the large object set rather than just checking if there are any objects with a specific position and combining these small sub-sets directly.

Approaches in multi-cast communication schemes [4], [5], [15] lead us to the idea of a region service. Such a service defines a certain geographical region and contains a list ob objects within this region.

Based on a software architecture consisting of COP- and visualization services [12], [16], we therefore extend this by a set of region services, each of them being responsible for a certain region. In its simplest form we can divide the earth (or at least our full operational area) into regions of the same size. Each of the spatial objects can than be added to one of the region services in constant time. To detect the objects within the area of interest (AOR) for a user, we now only have to request the objects from those region services that overlap with the user's AOR. This takes $O(N/R)$ time on average for each region service, with *R* being their number.

Unfortunately, the objects in a military domain are in general not regularly distributed around the world but concentrated on the battlefields. We can hence expect many units being located in Kabul or Iraq, but probably (almost) none in, e.g., the Antarctic. An adaptive approach to definition of region services takes the actual distribution of objects into account. A quad-tree (in the case of 2D coordinates) of region areas allows region services to be defined in such a way that they all contain (almost) the same number of objects. This leads to a constant time algorithm for retrieving the objects within an AOR, provided the size of the AOR is small compared to the whole battlefield.

The concept of region services not only improves the efficiency for generating a static COP but can also handle dynamic changes of object positions. In general all objects – except for those installed at a fixed place – can move. This means that the objects within and near the AOR of a user may change their positions and hence may leave or enter the AOR dynamically. However, not only the surrounding objects but also the user itself may move. Therefore a static computation of the AOR (possibly extended by a small surrounding of the AOR) does not work. Instead we have to compute the AOR dynamically. If an object changes is in the area of region service that overlaps with our AOR, we can subscribe to that object to be informed about changes of its position (and other attribute values). If that object leaves the area of the region service and is thus out of our AOR, we can cancel the subscription of that object. If, on the other hand, an object changes its position such that it is entering the area of one of the region services that overlap with our AOR, we can immediately subscribe to it. We therefore only have to check for a limited amount of objects if they are within our AOR.

We are currently about to implement this in an experimental service-oriented network-based C2IS. For the final paper we also plan to provide some simulation results demonstrating the effectiveness of our concept.

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