The Use of Simulation in Determining Operational Needs (WIP)

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ABSTRACT
Over the past five years, the Canadian Forces Warfare Center (CFWC), a unit within the Canadian Joint Operations Center (CJOC), has conducted a series of experiments referred to as the Coalition Attack Guidance Experiment (CAGE). These are structured as human-in-the-loop experiments, conducted at an operational headquarters level by in situ military personnel assuming operational roles. Although each CAGE has had its own emphasis and purpose, the focus of the most recent CAGE was battlespace deconfliction. This included the physical and electronic requirements of each operational position in a Headquarters, such as the command and control systems for joint fires support co-ordination.

The interaction between participants and their computers was recorded, providing the data for analysis. These results showed the applications that were most required and those that were not, as well as the applications that could be expected to use the most bandwidth. This information may be used in planning for the construction of a Theater Operations Center and in equipping the essential personnel.

Author Keywords
Operations Center Design; Experimentation; Virtual and Constructive; Battlespace Deconfliction.

ACM Classification Keywords

INTRODUCTION

Following a series of Joint Fires experiments and Human Factors experiments, the Canadian Forces Warfare Center (CFWC), a unit within the Canadian Joint Operations Center (CJOC), began conducting a series of experiments referred to as the Coalition Attack Guidance Experiment (CAGE). These experiments are both virtual and constructive, configured as human-in-the-loop, with appropriate military personnel assuming their customary operational roles, and conducted at the level of an operational headquarters or operations center. Although each CAGE has had its own emphasis and purpose, the focus of the most recent CAGE was battlespace deconfliction. This included the physical and electronic requirements of each operational position in a headquarters, such as the command and control systems for joint fires support co-ordination.

The motivation behind the conception of CAGE was the changing nature of military operations, with increased interaction among services (Army, Navy, Air Force) operating jointly in response to a complex environment, which often involves several intervening external agencies, in addition to the opposing forces. Such changes require the development of new concepts of operations and systems to manage the battlefield and provide effective engagement, while minimizing the potential for fratricide and collateral damage. In support of these goals, the CAGE series was undertaken to create and evaluate the utility of an environment consisting of virtual and constructive simulations and advanced command and control software. Participation involved the three services in distributed sites, within Canada as well as in the United Kingdom and Australia.

The scenarios were designed to be realistically complex, to create a plausible, relevant and challenging military and operational situation. The focus was on battlespace management events to provide opportunities to test battlespace deconfliction and joint fires. Typical scenario events included apprehending enemy forces, rescuing kidnapped personnel and providing support in mass casualty events. Each incident was supported by representative information typical of the level that would be expected by personnel in various positions within the tactical headquarters, thus allowing participants to play out their roles as if they were in a real operation. This is to say that the participants' actions were not scripted, but the location of personnel, equipment, buildings, vehicles, aircraft and ships was stated, and the scenario was given; from this starting point, participants would seek information to decide upon courses of action. Each position was equipped with the systems and applications required to function as if personnel were in an actual operation. Video

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feeds provided simulated views of the events as they transpired, and these views would change according to the decisions and actions of the participants, thus contributing to the realism of the experiment.

The experiment was conducted on a closed network, i.e. no access to the public Internet. This means that all services were hosted in-house. In real world operations, it can be necessary that networks such as these be set up with limited resources (e.g., bandwidth or software licenses). This is the reason why it is extremely important to have a full and deep understanding of exactly how operators use their workstations and the network that to which they are connected.

METHOD

To obtain data from experiments such as CAGE, the CFWC has developed software tools for monitoring participant interaction with their workstation.

One of these tools recorded details of the application in which the user clicked the mouse and where and what the user typed. This tool also performed a local packet capture on each of the workstations for a post-experiment analysis of endpoint network usage.

This tool was originally designed for workflow reconstruction and analysis [1]. More recently, it has been used to track the completion of targeting events and procedures [2]. In this paper, we show how these recordings were used to quantify the needs of individuals in a command center or headquarters.

In a military command center, application usage could consist of monitoring various data feeds or pictures for current situational awareness and reacting to points of interest. Unfortunately, the monitoring tool does not have eye trackers to tell when a participant is using a particular application by just looking at it. So, the major assumption taken in the paper is that the active application, i.e. the one the operator is "using", is the application that was last clicked or typed in. This is a reasonable assumption for the type of work that was done in CAGE, which consisted primarily of building information packages for planned missions and executing these plans with known tactics, techniques, and procedures.

Thus, it was possible to measure the system or application usage, as well as the bandwidth required per position.

RESULTS

System/Application Usage

Prior to deploying personnel and setting up a military Theater Operations Center, it is important to know the systems and applications that each position must be equipped with in order to fulfill its operational role. CAGE was seen as an opportunity to collect this information. The monitoring tools recorded the amount of time that a system or program was active throughout the experiment. Analysis showed that, of the approximately 100 systems and applications available to the participants, only 31 were used at all. (It should be noted that not all of these 100 applications would have been deliberately chosen to accomplish a task; some of these would have been programs resident in background features.) Among the more popular were:

- A Chat application for electronic communication;
- An application providing the Common Operating Picture (COP), and allowing for battlespace management (BSM);
- Microsoft Outlook, for electronic mail communication;
- Microsoft Word, for composing and reading information;
- Internet Explorer, for access to Microsoft SharePoint: the main document repository;
- Windows Explorer, for access to networked share drives (and basic Windows operation);
- Microsoft PowerPoint, for presenting and reviewing information;
- An application for video display; and
- A Voice over Internet Protocol (VoIP) application for telephone communication.

These accounted for over 90% of the total application use during the experiment. Most of the systems that account for the 90% of use, as well as those that account for the remaining 10% of use, are currently available to the community.

Prior to the experiment, three non-standard, specialized applications had been of concern due to various issues. However, the results revealed that none of these applications had been used more than 0.05% of the total time, and none had been used by more than 10 of the 75 participants. In fact, no more than two positions maintained consistent use of any of these applications.

In addition to the results of the participants as a whole, each position was analyzed as to its specific application use. A sample position, "Position A", is displayed in Figure 1. In this figure, the four days thought to be most representative of actual behaviour were chosen, and the relative amount of

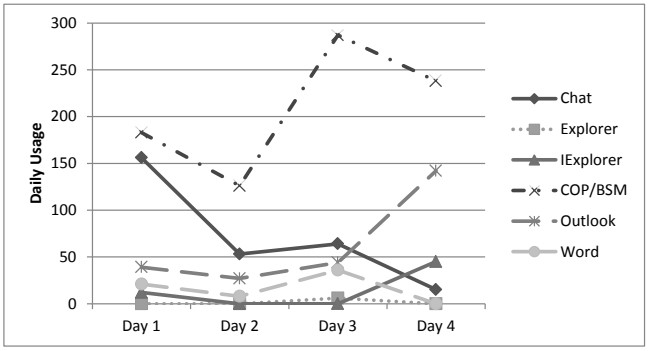

Figure 1. Sample Application Use Per Day, Pos.A

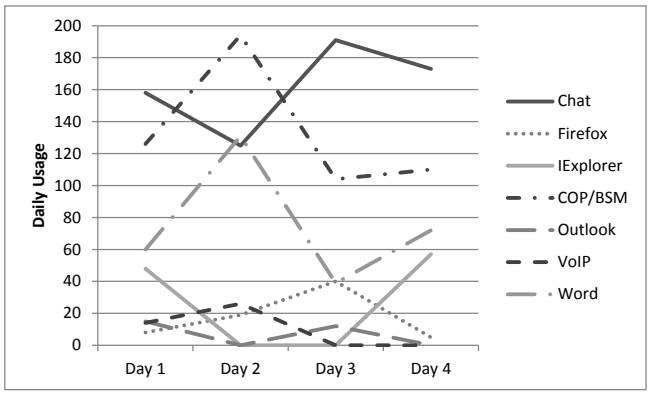

Figure 2. Sample Application Use Per Day, Pos.B

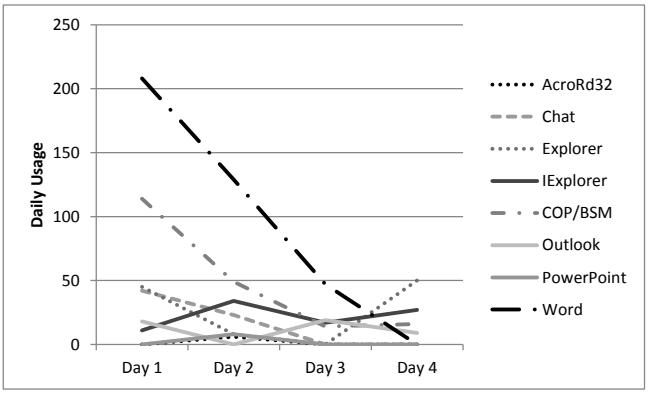

Figure 4. Sample Application Use Per Day, Pos.D

time spent in each application per day was plotted. Despite daily fluctuations, Figure 1 shows that the COP/BSM application dominates usage; numbers confirm its use at about 50% of the day. This is followed by the Chat application and Outlook, and more distantly, by Internet Explorer and Word. Explorer is used for only a few minutes on one day, which averages less than 1% of the time.

It may thus be judged that this position devotes most of his time to managing and maintaining awareness of the battlespace, and that two means of written communication are required. The applications that enable these functions should then be considered essential. Word and Internet Explorer are used lightly by comparison, but since they support common practices, they should also form part of this position's toolset. However, the limited use of Explorer might deem it to be non-essential in this case.

Sample Position B, showing data for the same four days as Position A, provides a somewhat different picture in Figure 2. Although the Chat and COP/BSM applications are dominant, as in the case of Position A, Position B shows much greater use of Chat. As well, Position B's use of Word and Outlook, with Word averaging 76 min. per day, are the reverse of those of Position A. Outlook and the other applications were used either inconsistently or at a generally low level, including Firefox, which would have been used to access another application specific to positions such as Position B. Knowing that this specific application is important in enabling Position B to perform his functions, the low level of time requirement should not be taken as a "no time" requirement.

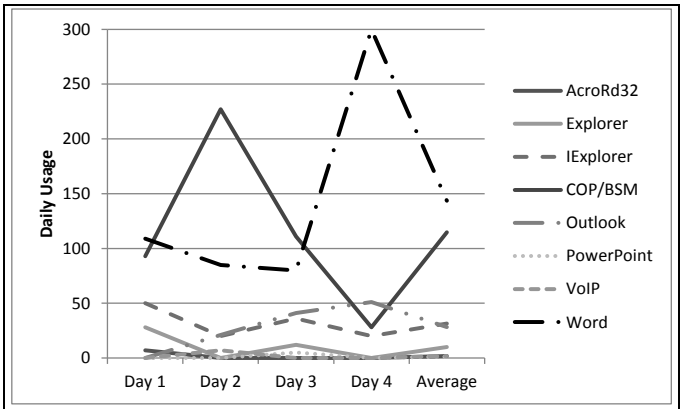

Figure 3. Sample Application Use Per Day, Pos.C

For Sample Position C, displayed in Figure 3, the application use shows more of a contrast with Positions A and B, in that Word is the most heavily used application. The COP/BSM application, again, figures prominently into use, followed by Internet Explorer and Outlook at a secondary level. The remaining applications show very low use. Position C would, therefore, involve considerable reading or writing and maintaining knowledge of or managing the battlespace, as well as performing research and communicating via electronic mail.

Figure 4, presents the application use of Sample Position D. This position's computer time shows a great decrease over the first three days, particularly in the case of the most-used applications, Word and the Cop/BSM application, as well as one of the less-used, Chat. This could indicate that this position performs an advisory role, and that his input would be of most value prior to action, or it could indicate a change in attendance and or some variability in execution of his role. In either case, Position D's operational requirements should be taken as those at the highest point of activity since it is apparent that this state can occur, and any limitations might result in an inability to fulfil commitments.

Thus, four selected positions show similarities in their application usage, though each displays its own differences. Application use is an important factor in knowing how best to equip personnel; however, there is another aspect involved in the planning of an operational headquarters which was also of interest in CAGE: bandwidth usage, which is the subject of the next section.

Bandwidth

One of the concerns with setting up a military Theater Operations Center is the bandwidth requirements of all of the pieces of equipment, particularly in consideration of any bandwidth limitations. CAGE provided an opportunity to

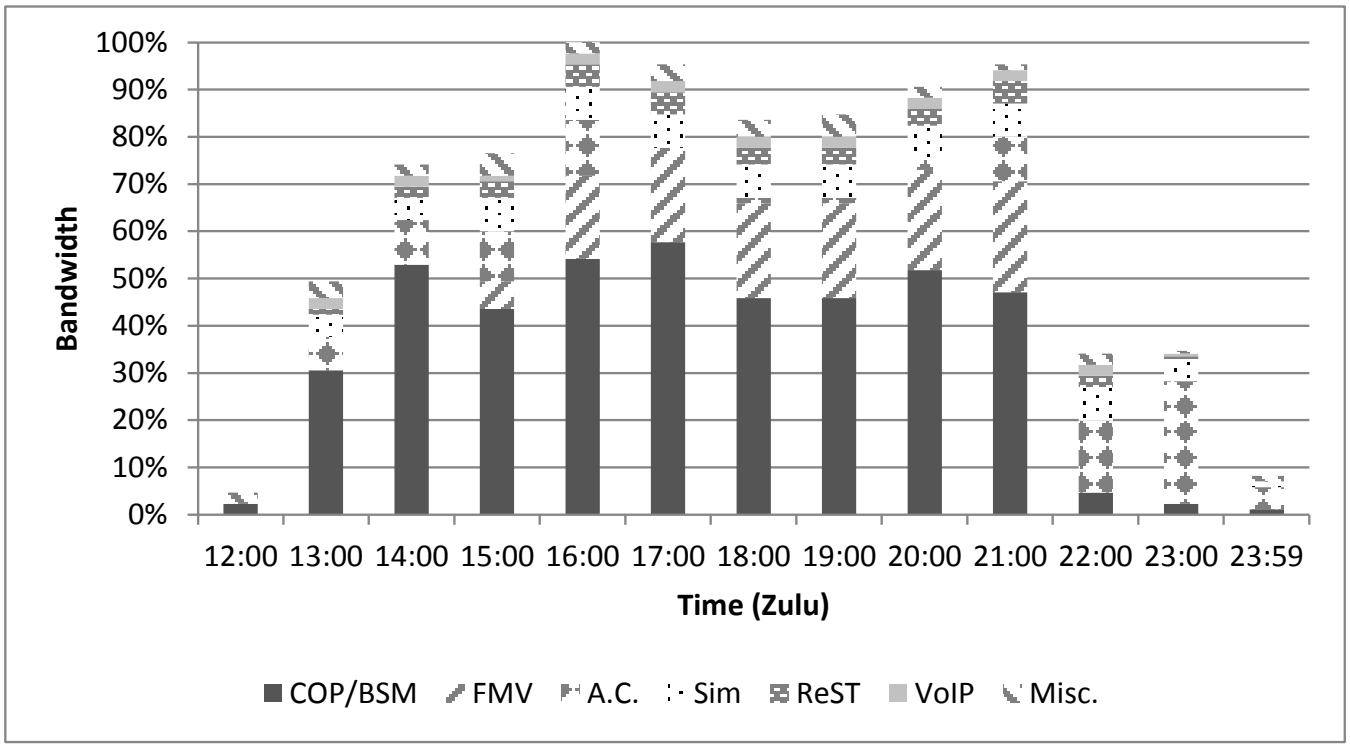

Figure 5. Total Bandwidth Throughput (%) Per Hour

quantify the bandwidth requirements on an experimental scale, and the potential to extrapolate numbers to the operational scale.

CAGE participants had a variety of systems and applications at their disposal, and these systems and applications had a wide range of bandwidth requirements. Observation of the daily bandwidth totals indicates that the major "users" of bandwidth were the COP/BSM application, Adobe Connect and Full Motion Video. Typically, the greatest usage was generated by the COP/BSM application, only surpassed occasionally by Adobe Connect or Full Motion Video during periods of high activity, or by small spikes of usage from miscellaneous applications and services during periods of low (or no) activity.

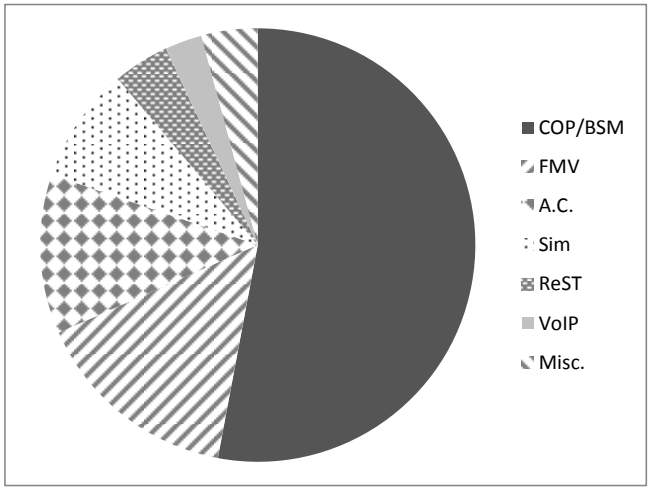

Figure 6. Average Bandwidth Usage by Application

Figure 5, displaying the highest activity day, shows the hourly bandwidth per application, normalized to the highest hourly total. The fluctuations can be related to the hourly activity: the day started at 8:00 (13:00 Zulu) and ended at 16:00 (21:00 Zulu), followed by a hotwash (i.e. a general discussion reviewing the day's events) which was facilitated by Adobe Connect. It can be seen that the COP/BSM application was used heavily during experiment execution time (13:00-21:00 Zulu); Adobe Connect ("A.C.") was employed during a morning meeting (13:00-16:00 Zulu) and late-day hotwash (21:00-23:00 Zulu); and FMV was transmitted from 15:00 to 21:00 Zulu. Peak bandwidth activity occurred at 16:00 Zulu, with the COP/BSM application accounting for more than half of the bandwidth. It should be noted that this graph represents the bandwidth use of all experiment participants; if it were restricted to the Theater Operations Center participants, the COP/BSM application use would increase, whereas it would decrease for the support participants.

The bandwidth usage for the day of highest activity is displayed in Figure 6. This figure shows that the COP/BSM application accounts for over 50% of use, followed by FMV at about 15%, Adobe Connect at 12%, Simulation Services ("Sim") at 9%, and other applications accounting for about 10% together.

Thus, the applications requiring the greatest bandwidth were determined.

CONCLUSIONS

The CAGE series was structured as a live, virtual and constructive simulated experiment, with personnel distributed nationally across Canada, and internationally, most recently in the U.K. and in Australia. Trained personnel, primarily military officers, assumed their customary operational roles, in jointly responding to various situations which had been designed to illustrate aspects of their behaviour. These situations, in turn, were altered in response to the participant actions, thus contributing to the realism of the experiment. All interaction between participants and their computers was recorded, providing a wealth of data for analysis. Two areas of interest were analyzed during the latest experiment: system or application use, and bandwidth.

The results showed the applications that were most required and, perhaps more importantly, those that were not, as well as the applications that could be expected to use the most bandwidth. It was determined that, of the 100 systems and applications available to participants, only a small subset was used, with an even smaller subset of about 10 applications used predominantly. The heavily used applications consisted of common software found on ordinary office computers, as well as a few other specialized applications, with the COP/BSM application of particular importance to participants. Considering bandwidth usage, the COP/BSM application, again, figured prominently, and daily events, including the transmission of video and the convening of distributed meetings, were reflected in bandwidth usage. These findings provide valuable information in planning for the construction of a Theater Operations Center and in equipping operational personnel. And since all of the information was founded on the simulated experiment, this demonstrates the important role of Modelling and Simulation in military experimentation.

Future work will involve examining the application and bandwidth requirements of all of the participant positions, refined to a smaller time frame, and consolidating the results to derive further knowledge.

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