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C2 Agility: Lessons Learned from Research and Operations
ISACC in Operations
Topics: 1, 2 or 3

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Abstract

The purpose of this paper is to present the concepts of ISACC, known as the Intelligent System for Advanced Command and Control that would help users improve their daily management of resources and operations. ISACC today has been deployed at both the Changi Airport (voted as the best airport in the world) as well as the Singapore Utilities for water management in 2013. Research and development are still continuing to look into deploying ISACC for the Singapore Police Force and other agencies with more mobile devices. The idea is to increase their C2 agility through more collaboration among the mobile forces, monitored by the Operations Centre. Four trials were conducted for the Singapore Police Force in managing Singapore's National Day Parade event. The second part of the paper will cover the lesson learned during these trials in the implementation and use of smartphones as part of ISACC for the Singapore Police Force. As smartphones becomes more pervasive in the world today, this paper will explain the value and lessons learned in using these devices for managing highly-mobile forces in operations, as well as ability for these mobile forces to synchronize their activities with each other, giving rise to better shared awareness among team members.

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INTRODUCTION

1. A plethora of books and papers have been written about Network-Centric Warfare (NCW) in the Information Age. NCW proposes a shift from the traditional military hierarchical command philosophy to a structure where forces are more nimble and operate on networks to increase their shared awareness as well as to self-synchronise with one another. However, while the concept of NCW is nothing new, it has existed for many years now as just that – a concept more than a real operational capability. Alberts, Garstka and Stein (1999) pointed out that the translation of the NCW concept into a real operational capability requires more than the implementation of information technology and networks. They defined a Mission Capability Package comprising concepts of operation, C2 approaches, organisational forms, doctrine, force structure, support services, and the like that is required to leverage information superiority in the realisation of NCW. This paper aims to present the Singapore Technologies Electronics (STEE) effort towards NCW by developing the Intelligent System for Advanced Command and Control (iSACC) to support civil-military and other agencies in their effort to address command and control of their resources and work objectives in a more intelligent and distributed manner.

2. This paper will first describe iSACC. The paper will later cover the Limited Objective Trials (LOT) conducted for the Singapore Police Force in their operations to manage security during Singapore's National Day Event as well as feedback gathered in using smartphone devices during the trial. Finally, the paper covers future work areas for iSACC.

THE CONCEPTUALISATION OF iSACC

3. iSACC was not conceived without a history of background work being done earlier by various researchers and organizations. Gompert, Lachow & Perkins (2006) argue that the networking power should be harnessed to generate cognitive advantages. They suggest that a network can be thought of in three ways: (1) as a *distributor* of information to individual minds; (2) as a *mobilizer* of many minds; and (3) as a *venue* for collective thinking. Accordingly, the cognitive advantages that may be derived from networks include (1) improving the individual's sensemaking of distributed information; (2) empowering more people with the authority to make decisions; and (3) fostering and harnessing the power of collective intelligence.

4. Following on this background, The Singapore Armed Forces Centre for Military Experimentation's (SCME) researched and experiment on 2 efforts. The first effort was the development of a Distributed and Integrated Command Environment (DICE) concept (Cheah, Fong, Toh, 2007). Cheah et el explained that DICE is a concept that enables forces to work distributed to deal with the complexity of military and/or civil-military operations in the world today. DICE proposes a command environment that would allow the Commanders or the organization to adopt not only the traditional military hierarchical command philosophy, but also a force structure where the edge elements, that is, the disparate ground units, are empowered with the information they need as well as the authority to collaborate and self-synchronize in the effective execution of distributed and dynamic operations as they adapt to the changing operational environments.

5. The second effort was to improve collaboration across echelon of commands. Between 2004 and 2007, the Sweden Armed Forces (SwAF) and Singapore Armed Forces (SAF) worked together to develop and experiment collaborative C2 planning models based on the new advancements in information technology. From 2008 this effort continued with the Swedish National Defence College (SNDC) and STEE. To address "the evolution of C2", Cheah and Thunholm (2010), authors and researchers from both the SNDC and STEE, co-developed a new integrated approach to military planning as an avenue to further improve shared awareness between staffs regarding command intent and the general understanding of the plan, as well as to increase speed of planning and re-planning in order to frustrate the adversary's objectives. The authors developed the Team Insight Model (Cheah, Thunholm, Chew, Wikberg, Andersson & Danielsson, 2005) and the Team Collaboration Model (Thunholm, Cheah, Fong, Tee, Chew & Larsson, 2006) as key innovations towards a more decisive and synchronized C2 planning and decision making process. The idea to develop faster and more collaborative planning models in order to increase shared understanding between staffs belonging to different echelons was brought about after some years of experience and practicing traditional hierarchical military planning process. Even with the evolution of newer technologies and information systems such as the Command Post of the Future (CPoF, Tisserand, 2007), it did not quite change the way the military did their sequential planning process (e.g. US Army, 2005).

6. In five different experimental studies between 2005 and 2009, Cheah and Thunholm observed that the act and effectiveness of collaboration performance among staff officers working within the same unit and also among staffs belonging to different echelons during military mission planning and battlefield

operations had challenges even with a very good collaborative software application system called **MissionMate** (later known as **GeniieMate** in 2008).

7. iSACC was conceptualized to improve upon **GeniieMate** to include other **Geniie** systems for civil-military operations and civilian agencies requiring Operation Centres. iSACC aims to provide the **visual integration** between GIS and Data, translating into an interactive visualization platform which is able to exponentially increase the value and usability of the data. It will bring data out of the constrictive spread sheets, static reports, and mono-focused dashboard widgets into the full context of location, time, and analytics.

8. Through the visualization capability, iSACC is able to provide the shared and fuzzed picture by allowing users to see all relevant data united in the full context of location on maps, time, analytics and alerts, thus allowing users to make well-informed decisions in a timely manner and responding to the situations with a better plan through its integrated capabilities. Like GENiiE-Mate and more, this means iSACC will encompass the ability to collaborate, provide on time resource management, a video management system, a better Data Fusion capability where information can be better visualize, provide trends based upon past data, and integration with other disparate systems with different communication protocols and message formats so as to get the necessary information integrated to the users.

9. To put into better perspective, iSACC was conceptualized primarily as an operational concept and process supported by the necessary systems, software infrastructure and Integration service. It improves upon the OODA (Observe, Orient, Decide and Act) that John Boyd (1976) wrote then. The iSACC concept is based upon a process of Monitor, Collaborate, Manage, Anticipate and Optimize. Figure 1 shows the iSACC concept of the 5 operational processes. The 5 operational processes can each be supported by individual system and when putting together, it can be seen as a whole system-of-systems approach.

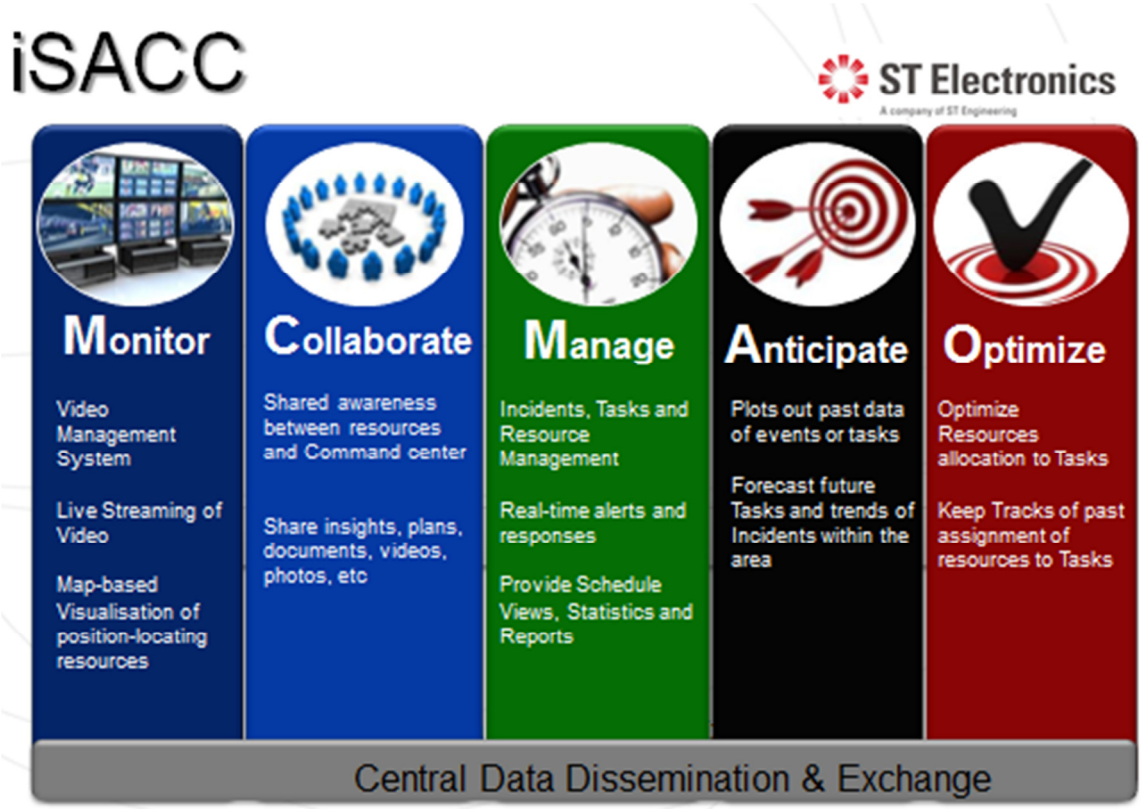

Figure 1 - iSACC Concepts and Process

10. The Monitor System is the basic need for Situation Awareness, as in John Boyd's "Observe" function. It is mainly driven by the eyes on the ground. Here in iSACC, it can be referred to both the video management system with remote cameras being placed at locations, and the actual eyes on the ground. For the video management system, the features required are real-time video streaming of live feeds from the ground, video recording these feeds, video playback and more importantly, video synchronized playback from two different cameras looking at the same area at the same time. If mobile forces are available on the ground, they could complement the video management system by using their smartphones to perform live streaming of the videos back to the video management system. It is also important to know or track where your resources are within the vicinity and this is done through a good map-based visualisation software. Traffic light colours are used to illustrate different statuses of resources and tasks being pictured on the map. Knowing the resources' locations aids the Operations Centre in making effective decisions to assign the nearest and appropriate mobile teams to attend to a specific task or incident.

11. The Collaborate System is to allow an operational user to collaborate with another colleague easily, thus allowing the organization to have distributed teams working in several locations, yet seen to be working together

as one integrated team. This mirrors the "Orient" portion of John Boyds's OODA loop. The intent of the Collaborate system is to share insights with one another, even with smartphone devices, by sharing documents, tasks, recorded videos, photos, text messages, map overlay drawings, and textual information in real-time. The Collaborate System is a natural progression from the Monitor System as the Monitor System is a one-way reporting process i.e. from the Resource to the Operations Centre. The Collaborate System is a two-way communication process that increases shared understanding of the mobile resources and the Operations Centre. Through the Collaborate System, it will lead to clearer ideas and objectives to be shared across the whole team.

12. The Manage System is the management of tasks or incidents at hand. This mirrors the "Decide and Act" portion of John Boyd's OODA loop. The idea of this system is to help Commanders or users to manage a number of tasks and dispatched the right and available resources to complete these tasks. It is also the intent of the Manage System to know who is working on the tasks now, and monitor their progress till completion with a schedule view. The Manage System should be equipped with a reporting module, to show the statistics for the number of incidents that have happened, the number of incidents and tasks acted on by the day, weeks or months, the number of resources being used for the incidents or tasks, the number of resources that did or did not arrive on time based upon the tasks received, etc. The system is a natural progression from the Monitor and Collaborate Systems similar to the OODA loop. However, for the iSACC concept and operational process, users will continue to use the Monitor and Collaborate Systems simultaneously even after the Manage System is kicked in, as each of the systems provide their respective value to the users.

13. The smartphone devices used by mobile forces complement all the above three systems in order for the actions to be assigned, tracked and achieved. For the smartphone devices, it needs to have a number of key functionalities. These include text messaging, ability to upload and retrieve files, photos, videos, map location of others and own, live streaming of video, and viewing the list of tasks and which tasks are being assigned.

14. iSACC provides an extension of the OODA loop by having 2 more processes for more advanced government or defence agencies. The Anticipate System is a step taken after a number of cycles are done with Monitor, Collaborate and Manage Systems. The Anticipate System is focussed on tasks or events that have happened and provide the trends. The system is also expected to plot out future tasks or incidents that might happen within the area. For example, based on past trends, if there is a fire on a 4-story apartment building, the system might prompt the users to anticipate about 20

phone calls from the public relating to the same type of incidents. This would help the users to anticipate the actions they require to accommodate such calls from the public. The system should also show as an example of a trend, after collecting past data, that the eastern side of a town is very prone to flooding in December periods due to rainfalls which will relate to possible high demands of resource responses to assist the citizens.

15. The Optimize System is the other process and completes the overall iSACC concept. While the Anticipate System looks at tasks and events, the Optimize system is focussed on optimizing resource deployments. It will keep track of past assignment of tasks being allocated to each resource and how long would a resource or a force take to complete the task. For example, anything within 15 minutes of travel time by a resource force, it would take this resource force an average of 2 hours to complete a small fire incident before the resource force is available again for assignment. This knowledge becomes an input rule into the system to be used when assigning resources to a small fire event. The Optimize System works hand in hand with the Anticipate system. Users will also have the flexibility to key in some rules and constraints to the Optimize system. As an example, in the month of December where flooding is expected, the users can input rules to place 5 more resources over and above the normal availability of resources. The Optimize System can be extended to include a simulation or the "what-if" on the day where incidents or tasks are higher than expected, and provide users with a comparison of the usual normal resources on standby versus 5 more resources on standby. Together with the Anticipate System, the Anticipate-Optimize Systems provide the "sensemaking" portion that is not explicit in John Boyd's OODA loop.

16. The iSACC system is as shown below in figure 2. The STEE team has been researching to develop C2 systems since 1999, with an in-house **CAP** (Common Application Platform) library of re-useable components and framework to help quicken bespoke developments. Today, the iSACC system is built on the CAP principles as well as using the suite of **Geniie** products. These Geniie products, which are prefix with a "g", include **gSiris** (a video management system), **gMobiMate** (a web-based software and mobile app on smartphone devices), **gCAD** (a map-based task and incident management system) and **gBridgeGate** (an Enterprise Service Bus for integration to other systems). iSACC is also largely based on **Microsoft's .Net platform**, a very mature platform for enterprise-grade solutions today. Other reasons for choosing this platform includes the cost effectiveness and the better integration with the office productivity tools, Microsoft Office, especially Excel and PowerPoint, which are used widely in most users' environment. That being said, there are components where Java platform can be leveraged on if the

client so desires, through the use of Web Services. This will not be elaborated here in this paper and will only be dealt in tenders of need.

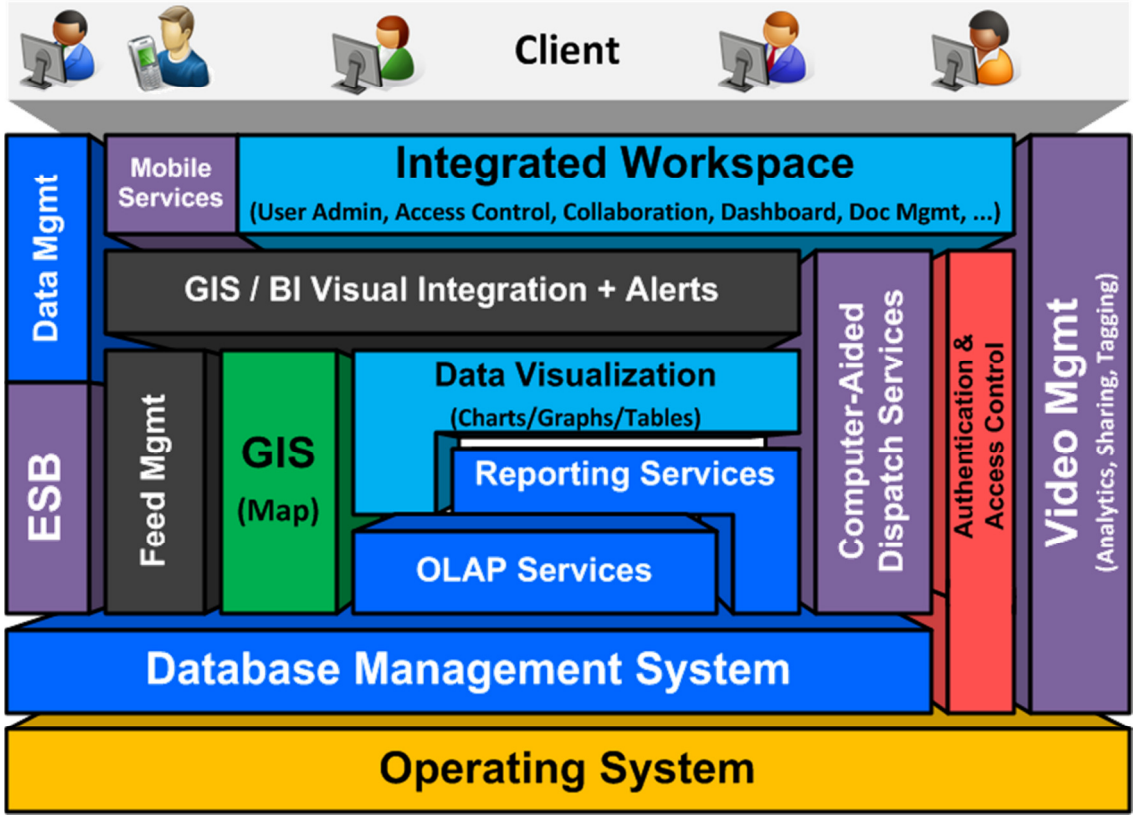

Figure 2: The iSACC system

17. Poole (2009, p. 758) says: "We may safely assume that future technological reliance will not decrease or diminish anytime soon". It has also been concluded in several studies on interagency collaboration (e.g. Miller, 2008) that although policies for comprehensive information sharing and collaboration between different agencies may still be lacking, the necessary culture to utilize information technology to facilitate collaboration does exist. Thus, iSACC is STEE's own initiative to create the culture for users to utilize and embrace information technology.

LIMITED OBJECTIVE TRIAL (LOT) FOR THE SINGAPORE POLICE FORCE

18. The Singapore Police Force or SPF has a regular need to manage security of any major public events. One example is the National Day Parade event for Singapore on the 9th of August every year. This event, which is being organized by the Singapore Armed Forces, is an annual event held at the City of

Singapore. In this event, there would be a spectator of around twenty-five thousand people and performers that sometimes numbers up to five thousand.

19. STEE was called by the SPF to help them manage a team of security personnel doing regular patrols of the surrounding environment around the Parade vicinity. Their objectives were:

a. To be able to communicate with all patrols within the area so as to get real-time updates of the activities that is happening within the vicinity (Collaborate).

b. To be able to assign tasks to any resources available to act on an incident that has happened (Manage).

c. To update the Operations Centre of the incident's resolution progress by the patrol forces on the ground with evidence of photos or videos (Monitor).

20. Without the iSACC system previously, the SPF was using only walkie-talkies to talk to the patrol officers walking the ground. With walkie-talkies, only one patrol could talk at any one time back to the Operations Centre. In addition, whenever the patrol was communicating back to the Operations Centre, it became noisy as there were other functional groups at the Operations Centre that needs to speak and communicate to other mobile groups which include traffic police, VIP escorts, etc. The patrols had to report clearly over voice communications of the events on the ground especially when an incident had occurred. They did not have any system to help them send video or photos back to the Operations Centre. It is the hope that iSACC would be able to help the SPF overcome these disturbances in operations and improve their overall situational awareness.

21. In this LOT, STEE used the iSACC concept of Monitor, Collaborate and Manage, to facilitate SPF in their security operations of the event. Four trials were conducted for SPF. All trials were with crowds and performers at the actual location, out of which two of the trials were children spectators from primary schools, one of the trials was for the preview event and the final trial was the actual National Day of Singapore itself.

22. The Operations Centre was using a Web-based system that includes a map, icons, text boxes, ability to send text messages to the smartphones, create tasks/incidents, assign these tasks/incidents to the patrol forces on the ground and finally tracking the resources to the completion of tasks. Screen shots of the Web-based iSACC System are shown below:

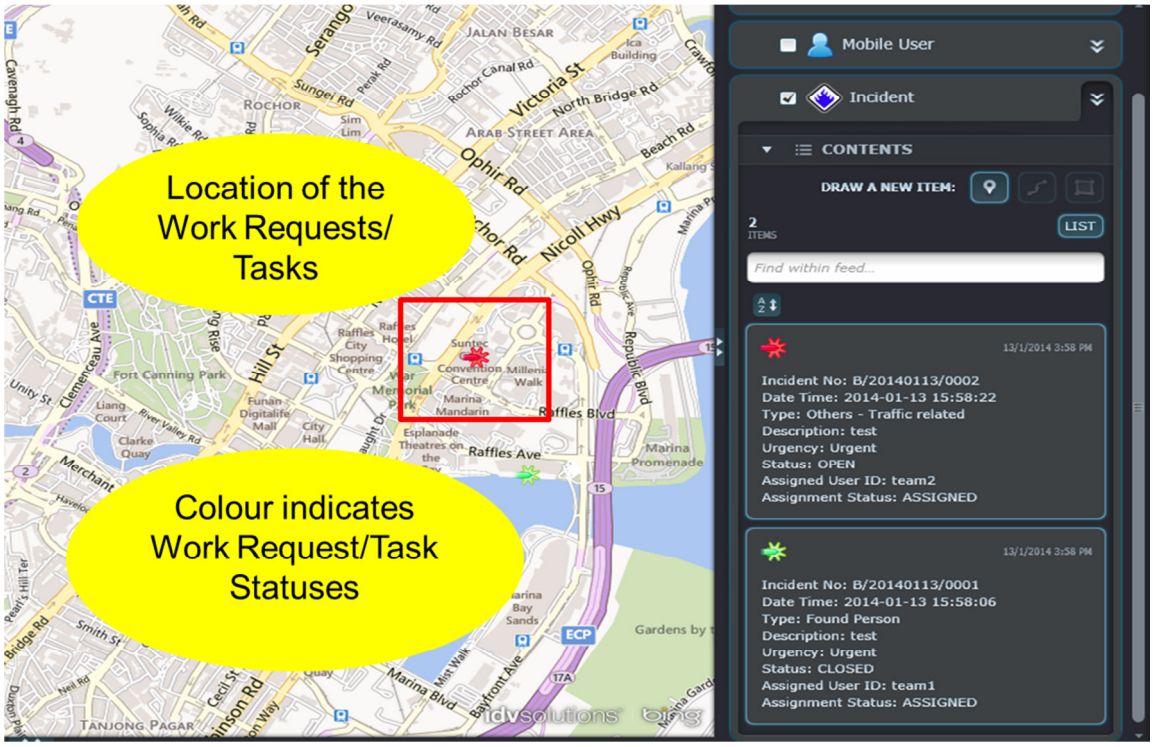

Figure 3: Situation at Glance – Location of Tasks/Incidents

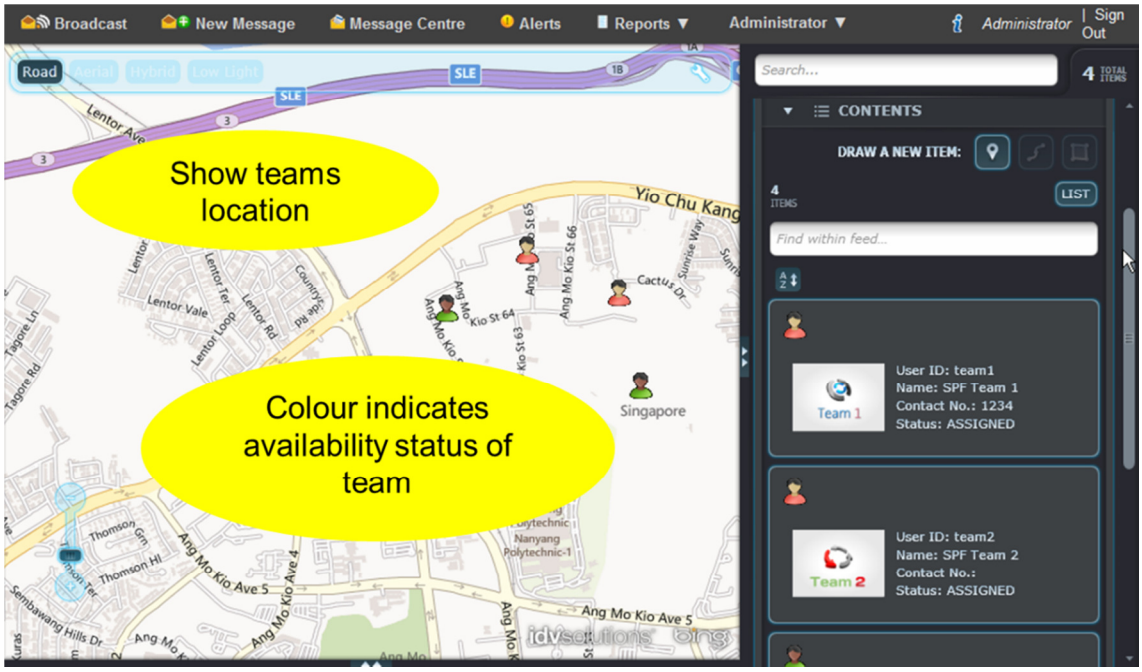

Figure 4: Situation at Glance – Locations of Teams/Resources

23. Each of the patrol forces were carrying smartphones (iPhones) that is installed with an iSACC app. The app was called as gMobiMate. The app allows the patrols to text messages, create tasks/incidents, accept a task or

incident that was assigned to the patrol, as well as update the incident with attachment of photos or videos.

Figure 5: Screen shots of the gMobiMate App on the iPhone

24. For each of the trials, the patrols and the Operations Centre personnel were all different personnel on duty. Thus, quick training on the usage of the system had to be done prior to each of the trials. This implies that there could not be any learned usage of the system in subsequent trials by the same personnel. Learned usage will lead to better understanding of how the system can be used to fit their operations, as well as finding ways to overcome the limitations that the system has when exploiting it for situation awareness.

25. All trials proceeded successfully and facilitated the Operations Centre in better awareness of the environment. The iSACC System was found to complement the SPF's Video Management System, which was put in placed prior to the event. The iSACC system allowed the SPF patrol forces to walk in areas not covered by the SPF's video surveillance cameras and increases their awareness through video and photo files being uploaded and text messaging. The use of the gMobiMate app on the iPhones helped the Operations Centre with real-time updates, thereby increasing situation awareness of the security operations besides having to have the Operations Centre at a vantage position as shown below. The Operations Centre was situated on the 19th floor of a Hotel to overlook the entire event.

Figure 6: The SPF Operations Centre overlooking the Event

Lessons Learned in Using Smartphone Devices During LOT

26. There were a number of lessons learned when STEE conducted the trials for SPF using Smartphone devices in collaboration with the Web-based software at the Operations Centre. One of the feedbacks gathered about smartphones is that the device battery gets flat very fast if the iPhone app is constantly in use. Having the Operations Centre to be alerted that any of the smartphones have about 20% of battery usage left would help benefit awareness. It leads to instructions to charge the battery or replace the battery (if it is an android phone). This also helps to prevent miscommunication between the mobile teams and Operations Centre, as Operations Centre is aware that this mobile team smartphone's battery is left with 20% usage and it might run out anytime, thus unable to respond to Operations Centre instantly should the mobile force not replace or charge the battery of his smartphone device.

27. A second lesson learned was that mobile teams now equipped with smartphones were able to capture photos during their tasks assignments. This helped to improve their updates. A picture paints a thousand words. Having

the photo being tag to a location could help improve situational awareness at the Operations Centre as well as reduce any chance of misrepresentation. The Operations Centre would be able to assess the severity of the situation.

28. A third feedback that STEE gathered from the SPF was that the mobile users would like to have more bandwidth in order to send Video across to the Operations Centre. Video paints a million words and creates higher awareness in the Operations Centre. Feedback also gathered that the Operations Centre users would want to view the environment "live" at times for areas that the remote video cameras placed on the ground could not cover. Many had asked if smartphones devices could do such "live" video streaming. To do live video streaming, bandwidth efficiency and compression techniques are very essential. An Operations Centre with video surveillance capability will then have the flexibility to view from smartphones and/or from surveillance cameras. This idea, however, requires smartphones to have good battery life and optimized camera quality. Smartphones equipped with 4G capabilities are also preferred, although 3G enabled smartphones might do the job, albeit with a low-bandwidth video streaming application software.

29. The fourth lesson learned was that apart from the desktop Web-based software at the Operations Centre who can allocate out tasks to the resources on the ground, the head of the mobile force would also want the ability to assign tasks to his own resources via his smartphone as well. In other words, he wants to act like a mini mobile Operations Centre on the ground and be able to do all these through his smartphone device. This idea means that the gMobiMate app must have intuitive interfaces, big buttons, easy to use and have a map of where his team members are. Should there be two mobile team leaders on the ground and of close vicinity to each other, there is a need to introduce some form of collaboration (chat or text) among them to synchronize and agree on who is in the best position to act on the task when it is at a location where both can act on it equally well.

Future Work Areas for iSACC

30. In conclusion, iSACC has significantly provided the SPF with improved situation awareness between the patrol forces and the Operations Centre. Teams were able to collaborate effectively with less voice communications being used as well.

31. With the above lessons learned about smartphones and the usefulness of collaboration between the smartphone app (gMobiMate) and the web-based

software at the Operations Centre, the STEE team will be looking at further improving iSACC for three different levels of users. These three levels are for:

a. Small enterprises, that need to have a cheap system to help them solve their immediate operational needs.

b. Medium enterprises, that need to have quick customization of the system to help them improve their operations.

c. Large enterprises or government agencies that require in-depth customisation and the "Anticipate-Optimize" tools to help them advance their current operations to a higher service satisfaction level seen by the public.

32. Common across all three sectors of users are the use of smartphone devices. As there are three different levels of users, iSACC will be configured into three forms.

33. The first form that iSACC would take is for the small enterprises need for daily operations. These types of enterprises include delivery operations such as food and furniture deliveries, maintenance operations, event manager companies, etc. An app called gMobiMate would be available for their use by downloading from the Apple Store or Google Play Store. gMobiMate is also accessible as a Web-based software by desktop PC, laptops, and tablet PC. The STEE team will be looking at improving the useability of the Web client and mobile app that will include allowing the mobile team leader to also designate tasks to his mobile teams. The approach to be adopted will be to use as much Internet services as possible.

34. The second form that iSACC would take is for the medium enterprises need in operations. These medium enterprises differ from the small enterprises as they have a larger number of workforce in operations and have differing needs and management responsibilities, particularly where tasks and incidents are concerned. For the medium enterprises, the form of iSACC would be in a form of a lightweight Computer-Aided Dispatch (CAD) system called CAD-lite. CAD-lite, in similar fashion to gMobiMate, will involve tasks or incident monitoring, and resource management. For this form, the intent is to look at managing, dispatching and tracking resources assigned to the tasks more definitively. This means having:

a. A duty roster module to identify personnel and vehicles on duty.

b. Configuring the personnel and vehicles to various special types of tasks at hand.

c. Providing features that enables the Operations Centre to create various pre-planned response plans to match special type of tasks and incidents.

d. Providing geo-fence notifications when a personnel or vehicle arrives at the scene and leaves the scene.

e. Dispatching the resources and vehicles by providing them with a smart routing and attachment of documents to give more information about the tasks or incidents.

35. The third form that iSACC would take is for the large enterprises or government agencies need in C2. It is to note that these large enterprises or government agencies are likely to have some form of C2 systems in place. Thus, the STEE team have to be mindful that there will be a bigger need for bespoke developments for each large enterprise or government agencies, and they differ quite significantly. For example, the operations of the Airport will be vastly different from the operations of the water or energy agencies, as well as different from the military or the police. There will also be differing system preferences among these users. For example, various agencies will have differing map or GIS (Geographical Information System) needs, messaging variation, communication protocols, different development platforms and many more. Some will prefer the GIS to be in ESRI, while others prefer the GIS software to be of open source.

36. With the awareness that iSACC need to cater for differing enterprises or government agencies, the third form of iSACC cannot be a natural extension of gMobiMate or CAD-lite. The third form of iSACC has to provide good value for money to these agencies and the intent is to focus mainly on the Anticipate-Optimize Systems as earlier described and to provide visual integration of GIS and data. We call this visual integration as Visual Intelligence or Visual-I in short. Visual-I will primarily be a map-based application with side panels that include trends of events, or a history of events that has happened and being related to the location on the map. It will also have specific templates of the resources and the hours it takes to complete specific tasks (e.g. deliver 100 gallons of water to a location, put out a small fire at the park, etc). These templates are captured and collected by the Optimize System overtime. The Anticipate-Optimize Systems are continuously working in the background to collect and display the incrementally growing and changing Visual-I picture to

the users, while the users use the Monitor-Collaborate-Manage Systems to accomplish their operational duties.

37. To do the third form, there is a need to engage users in experiments or LOT in order to understand their threshold levels, past trends of events or tasks, and their decision making process particularly where resources are insufficient to handle the tasks at hand. The STEE team will address the third form of iSACC when we have linked up with a user willing to engage STEE services.

38. Common to all of the above is the need for the smartphone devices, and to pack more software capabilities into them, incrementing purposefully from gMobiMate to CAD-lite and to iSACC. Between the CAD-lite and gMobiMate, the key improved capability will be the smartphone device ability to send low-bandwidth video streams back to the Operations Centre. The other key capability at the CAD-lite and iSACC levels will be to install the EMM (Enterprise Mobility Management) application. With the EMM application on your smartphone device, users at the Operations Centre have the flexibility to configure the smartphone devices remotely, as well as adjust the permissions or restrictions of applications to the devices when entering a more secure area or where networks have low signal strength.

39. The above description gives a summary idea of where the iSACC system is heading to assist different levels and different types of users in accomplishing their operations or missions more efficiently and effectively.

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