Network Centric Mapping Database

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BIOGRAPHIES

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Walter J. Altice has obtained over seven years of professional experience in computer networks and system design. Mr. Altice worked as a network administrator for the City Of Virginia Beach and was awarded the Class Act Award through superior support and service. Mr. Altice also received a Bachelor of Science degree in Computer Engineering with a minor in Computer Science from Old Dominion University in 2002. Mr. Altice's primary interests are developing 3D navigation applications using OpenGL.

Robert P. Cooke:
Robert Cooke has managed Information Technology assets and software intensive development projects for over 10 years with the U.S. Navy. Mr. Cooke received his Bachelor of Science degree in Computer Science from Old Dominion University in 1987, and earned his Master of Science degree in Information Technology Management in 1996 from the Naval Postgraduate School in Monterey, CA. Mr. Cooke currently directs the Information Technology Department at W R Systems, Ltd. (WRSystems)

Robert A. Greer:
Robert A. Greer is the Advanced Concepts Chief Engineer for the Space and Naval Warfare Systems Center, Charleston (SPAWAR). Mr. Greer received his Master of Science in Electrical Engineering degree in 1991 from Old Dominion University, Norfolk, VA, and a Bachelor of Science in Electrical Engineering degree from the University of South Carolina in 1984. Mr. Greer's efforts are primarily devoted to developing and fielding advanced electronic charting / navigation systems in the Navy.

Zhengyu Yang:
Allen Yang has obtained over five years of professional experience in computer software design and implementation. Mr. Yang has been working as a software engineer for WRSystems designing Navy R&D software. Mr. Yang received his Master of Science degree in Computer Science from James Madison University in 2001. He also has a Bachelor of Science degree in Computer Science and Mathematics from Bridgewater College (1998).

ABSTRACT

This paper examines the military and commercial benefits of developing a Network Centric Mapping Database (NCMD) server to host navigational data of various resources. The NCMD server functions much like a terminal server in that it allows simultaneous access by different mapping software applications. The NCMD server is platform independent and capable of providing mapping data to two- and three-dimensional (3D) vector-based mapping software applications. The NCMD server will provide multiple points of access resulting in increased overall fault tolerance. The NCMD concept involves a multi-tiered global network. Updates to the NCMD server are automatically performed from a single point. Clients are guaranteed to always have the most updated map data. Clients using NCMD will have the ability to post updates to the Global NCMD server. Client applications can download mapping data from Digital Nautical Charts (DNC™), Digital Terrain Elevation Data (DTED), Tactical Ocean Data (TOD), Digital Bathymetric Database (DBDB-V), Vector Map (VMAP) data, and the National Oceanic and Atmospheric Administration (NOAA). The local clients will also be able to retrieve weather, water current, and tide information. The client can download any part of the mapping data on the NCMD server according to the current position or specific mapping data request. The NCMD concept will save money by reducing the amount of manpower to update charts. NCMD will eliminate the time required for manual correction and delivery of updated paper charts. Currently, seven men are involved in updating charts on a CG cruiser. NCMD will reduce the amount of manpower, possibly saving the U.S. Navy up to $100,000.00 annually per ship. The client will be configured to share information with other clients in the same region, such as route and mission planning, navigation aids used, best practices, etc.

INTRODUCTION

NCMD Conceptual Architecture:
The NCMD global network will be multi-tiered and dynamic. The NCMD network architecture consists of local servers, regional servers, and a global server.

(Figure 1) The NCMD concept will provide data synchronization, fault and disaster recovery, and built-in redundancy. Clients using NCMD will connect via TCP/IP. TCP/IP is used for adaptability, open architecture / platform independence.

(Figure 2) The NCMD concept would leverage the FORCENET infrastructure as its network backbone.

Figure 1


Figure 2

Global Server:
The global server will always contain the most up-to-date nautical chart data and be accessible by any local or regional server. One of the primary functions of the global server is to provide updates to all the regional servers. The global server can be rebuilt from the regional servers increasing fault tolerance.

Regional Servers:
The primary job of the regional servers is to keep updated data of a specific area and time. The regional servers will also be able to act as a back-up protocol in case of a global server casualty. Any regional server can get charting information and updates from other regional servers that have this information stored in the event of a global server casualty. Each regional server will store small sections of mapping data from another region to improve fault tolerance and recovery time. If a regional server were to go down, the data could be retrieved by the client through other regional servers. Furthermore, the down regional server could be rebuilt with data on the global server or other regional servers. The regional server may also keep track of vehicle positions for contact information, fleet awareness, and strategic planning.

Local Servers:
The local servers will obtain the charting data from the regional server and be cached locally. If the regional server is down, the local server may get data from other local servers, other regional servers, or the global server.
Another important aspect of the regional servers is the ability to update data on the global server. Future capabilities of the local server include sharing routes and contact information between clients.

NCMD Data packet Database:
The NCMD database will provide quick access to filenames, last updated dates, classification, and availability of mapping data. Each server will contain its

own database of local available data. The table names in the database are organized by .5 x .5 minute areas and labeled "Longitude Hemisphere Degree Minute Second Latitude Hemisphere Degree Minute Second" Format. Figure 3 depicts a table containing only four data libraries.

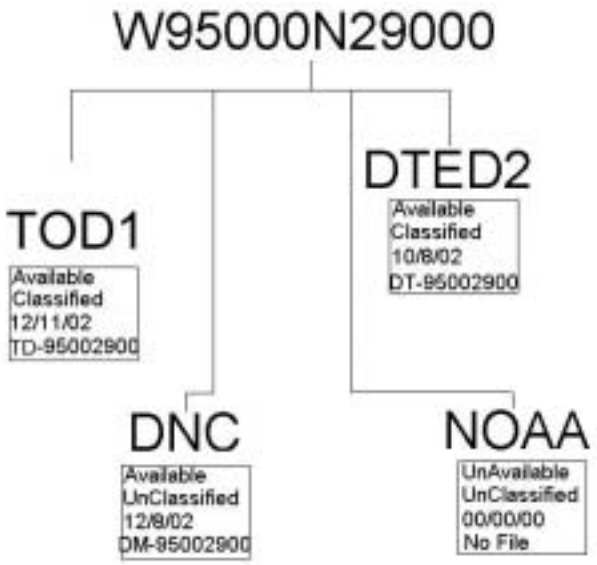

Figure 3

A typical table will contain information for all of the libraries and series of each library. The database will not store weather, water current, and tide information. This information will be obtained directly by the local or regional servers. Since the database is organized by .5x.5 minute area tables, the number of tables in each database should never change. The primary focus of the NCMD database is to keep track of where, what, and which data is on the server. As a client's current location is sent to NCMD, the database will find the table based on where this area is. Next, the table will be searched for what data sources where requested. Finally, the database will determine which files to compile based on classification, availability, and updated data. The NCMD database has great advantages, such as the ability for a client to request additional mapping data. Since the data packets are divided into categories on NCMD, it will be easy for a client to request a specific navigational aid without the need to re-download the full data packet with bathymetries or terrain elevation data. The database makes compiling multiple or single data packets easy since the data packets on the NCMD are not pre-compiled.

NCMD Data Packets:

The data packets locally stored on NCMD are organized files with a .5 x .5 minute area or roughly 900 square miles. These files are organized by the data series and type of navigation aid. Figure 4 is of average files sizes for DTED2 with 25% terrain coverage, NOAA, and DNC mapping data in a .5x.5 minute area. The total file size is the result of all three compressed together. This is the average file size that would be transferred to the clients during nautical navigation.

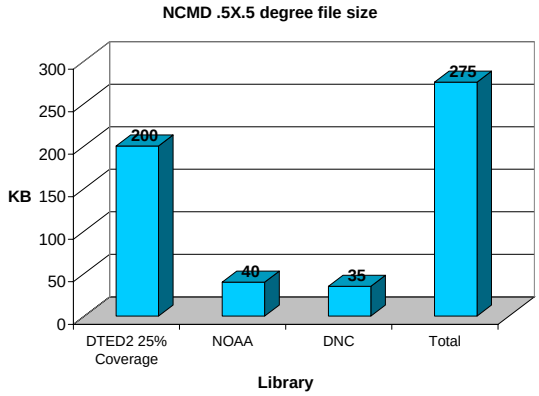

Figure 4

This compressed data packet received from NCMD will contain the best possible bathymetry and terrain data available. The client is then able to display the highest quality visualization possible with the combined data.

NCMD data packet transfer:

The Client will send NCMD the current location in Longitude and Latitude degrees-minutes-seconds format. This connection to NCMD will be secured through encryption methods such as a Virtual Private Network (VPN) connection. The download times will vary greatly from the connection speeds. Figure 5 displays the estimated download times for a 275KB compressed file in seconds.

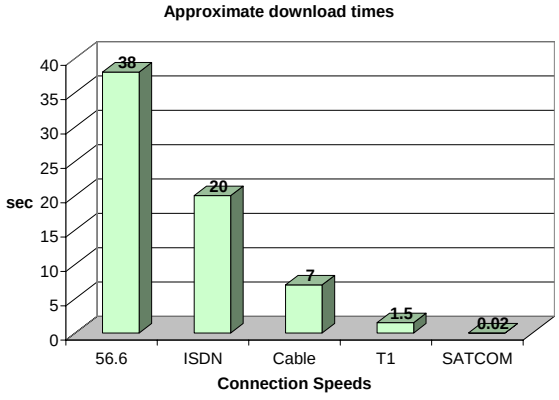

Figure 5

It is the job of the client to request data when needed. NCMD is only designed to provide data for the area requested. Ideas such as database control and position tracking on the server side have been discussed. However, having the clients pole the local servers with current

position was not desirable due to bandwidth and performance issues.

NCMD Updates:
Updates to the NCMD servers are totally automatic and dynamic. The local, regional, and global servers will always be updated automatically. The primary source of these updates is obtained from clients and library source updates but may also include Web-based updates. Users may find discrepancies in the charting data and request a correction or update. The global server is where all requested updates are stored prior to verification. All updates from the clients are passed through the local and regional servers to the global server where this information is verified. The global server will save the requested updates for reference and will notify the original resource for correction, such as the National Imagery and Mapping Agency (NIMA), the National Oceanic and Atmospheric Administration (NOAA), etc. Once the new mapping data is verified, it will become an update. All other updates, direct ones from the updated library source or via Web resources, are performed directly to the global server and will not undergo further verification. The updates to NCMD mapping data include bathymetric data (sounding data, coastal line data, and contour data), navigational aids (buoys, light towers, and range lights), land-elevation data (DTED data), weather data (weather, current and tide data) and any other data that is found to be inaccurate or unnoted. Updates will only have to be performed once on the global NCMD server and clients will no longer have the need to store vast amounts of data locally.

NCMD Receiving Updates:
To receive an update, the client must request this particular area. Figure 6 defines the data flow of the update process through the NCMD network. Updates will only be propagated to the regional servers. The updates will not be propagated to the local servers until this area is requested by a client.

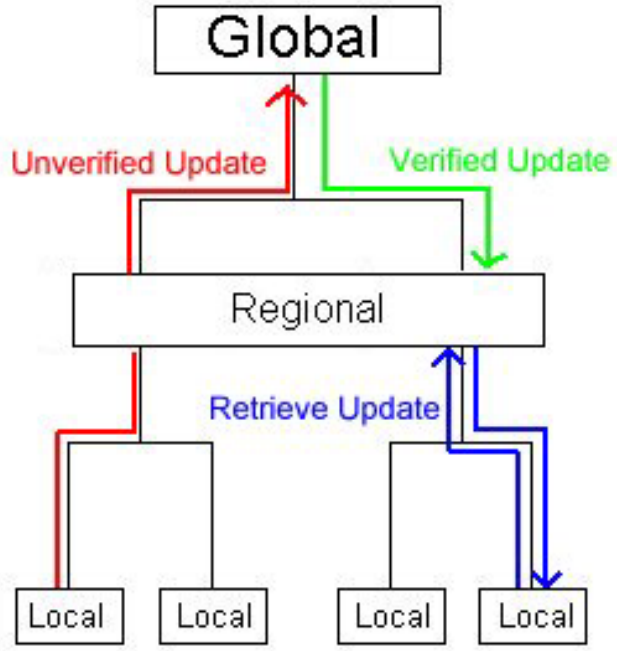

Figure 6

Once the client requests this area, the local server will check for updates at the regional level. This check involves a quick query of the update tag on each packet downloaded from the client. If an update exists or if this data was not previously available on the local servers, it will be downloaded and stored on the local server. From the local server the updates will eventually propagate to the clients as requested. Because the NCMD creates compiled data packets from smaller individual data packets, the client may obtain new updates without requesting the full compiled data packet.

NCMD Tide, Water Current, and Weather Data:
The NCMD regional or local server will continually receive updates from online weather and environmental servers for weather, water current, and tide information. The NCMD server will also provide the multidimensional imagery from polar orbiting and geostationary satellites operated by the NOAA or other available providers for daily, weekly, monthly and yearly information. NCMD also has the capability to correct weather, tide, and water current data. The local client will provide the unverified feedback to the regional or local server, if the information provided by the NCMD server needs to be corrected. The regional or local server will contact online providers for verification. Then the regional or local server will send the verified information back to the local client.

NCMD and 3D applications:
WRSystems is developing ICE Cubed, a 3D visualization program sponsored by SPAWAR. ICE Cubed uses

bathymetry and terrain data to display the contours of the ocean and land. Figure 7 is an ICE Cubed representation of the Baytown harbor in the Gulf of Mexico.

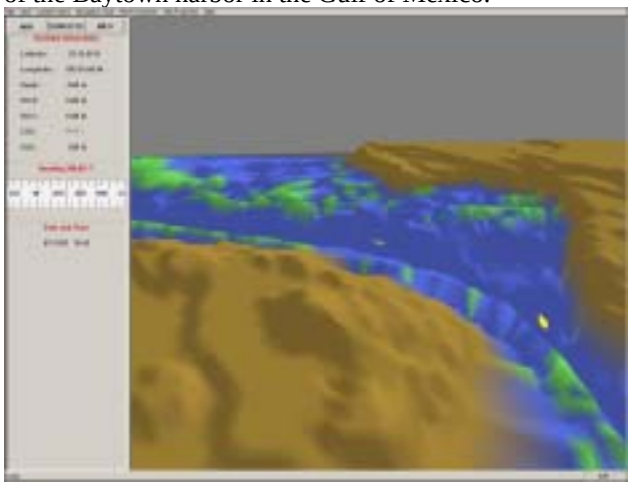

Figure 7

The potential use of ICE Cubed in electronic navigation, command and control, and situational awareness is unlimited. WRSystems is currently promoting ICE Cubed for situational awareness and a means of virtual training, reviewing maritime incidents, and instructional submarine navigation. The data ICE Cubed uses to draw 3D visualizations must have excellent resolution, worldwide coverage and combined elevation data. DNC bathymetries and DTED2 data (Figure 8) will provide worldwide coverage but the resolution of the ocean floor in most areas is not defined well enough.

Figure 8

NOAA and DTED2 data (Figure 9) will provide excellent land / water contour data but the data coverage is not worldwide.

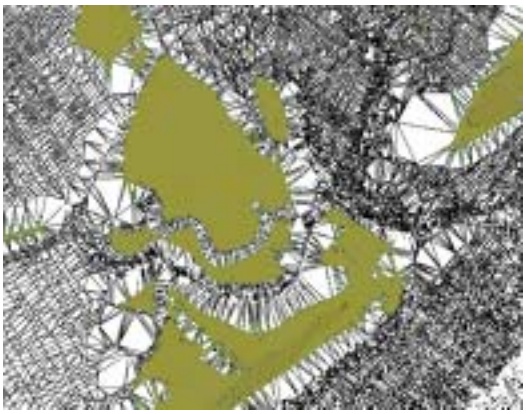

Figure 9

Combining all data sources will provide users with the best 3D visualization and worldwide coverage. Currently, to view a smooth, realistic 3D map image with good resolution, one would need to pull data manually from NIMA, DNC, DTED, TOD, VMAP data, NOAA, and Satellite Imageries (JPEG2000). For worldwide access this would be more than 50 gigabytes in CD data, not to mention the different levels of data from each set. In addition, accurate weather, water current, and tide information would have to be gathered from additional sources such as METOC. Even with the ability to store all of this data on a local machine or on a large number of compact discs, the problem of data loss and updates will still remain an issue. Due to the need for quick access to vast amounts of data, local storage limitations, and data vitality, ICE Cubed would not be practical for commercialization without the NCMD concept. ICE Cubed will use NCMD as the primary source for information.

NCMD and Vector-Based Applications:

The NCMD global network provides bathymetric data to other vector-based applications as well. The Integrated Charting Engine (ICE) is an application, which is being developed by WRSystems for SPAWAR (Figure 10) that will benefit from NCMD.

Figure 10

The 2D vector-based applications can download DNC, TOD and DTED datasets to generate the integrated chart. The constant weather, current and tide updates enhance the functionalities for 2D applications.

NCMD Issues:

The NCMD has three main issues:

The first one is that of security. The purpose of security is to make sure all transferred information has been encrypted so position information cannot be utilized by unauthorized users. The network architecture will use a packet-filtering firewall to protect the connection between the NCMD server and the client.

The second issue is classified information. It deals with ensuring that only a person with the proper level of security clearance is able to obtain sensitive information. The NCMD server assigns a unique username and password to each user. The user has to log onto the NCMD server each time in order to download information. The NCMD identifies the username and password. The server can then send certain amounts of information based on the user's security clearance level. Certainly, the higher the security clearance level the user has, the more detailed information the user can obtain from the NCMD server.

The third main issue is that of bandwidth. Due to the current network limitations on navy ships, it is very difficult to guarantee network connectivity. An unstable network connection may cause serious problems when the client's connection to the NCMD server is interrupted during a file download. NCMD will have the ability to continue a broken file download if the client loses the network connection and is unable to continually download the data packet from the server. When the client regains the network connection, the NCMD can pick up the last point and send the rest of information to the ship.

NCMD Conclusion:

The NCMD server will host navigational data from different resources, including DNC, DTED, TOD, VMAP, NOAA, and Satellite Imageries. The multi-tiered global network architecture will allow the NCMD server to perform from a single point and will increase NCMD overall fault tolerance. The NCMD will benefit the client by shortening response time during crisis periods. The NCMD server will reduce waiting time for delivery of updated charts to minimal by correcting charts automatically. The NCMD server will also improve mission planning by enabling real-time data pull by operational forces. Reducing the workload and providing information sharing between clients can be accomplished by using the NCMD server as well.

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