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A Fleet Technical Condition Management System for Connected Ships

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Ships are offshore transport or working platforms. We developed an internet-enabled fleet technical condition management system by making ship connected to shore-resided technical management center. Operational data are uploaded automatically to management center for data storage, condition monitoring, trending, analysis, statistics, trouble shooting, and make operation and maintenance decisions. For it possible to apply a single system to manage a whole fleet, several technical aspects should be standardized. Data is the most fundamental part including machinery operating parameters, alarms, failure modes, and some others. We individualize and code these data and make them standard across the whole fleet, on-board monitoring system capture operating parameters snapshot periodically and all alarms, code, package and upload them. The Fleet management center system is a WEB application; all functions of it are designed against data standard. When fully realized, most management functions can be automated, to improve reliability, availability and maintainability of the whole fleet.

1. Introduction

Ships are offshore transport or working platforms, operated in ocean or inland waterway, far across management office by a crew of several people relative independently. A ship operator usually operates dozens of ships, distributed in large geography. Land-based management office has strong desires to know their real-time operational and technical information, such as position, speed, fuel level, and major machinery operation parameters. Many institutions and researchers studied remote monitoring technology, to make ship connected with management office, to exchange information in real-time, and operate and maintenance the whole fleet better (Geng et al., 2004; Hu et al., 2009).

In other mobile vehicle areas, such as aircraft, trucks, and construction machinery, there are some kinds of fleet remote monitoring and management system and products, such as MyBoeingFleet by Boeing Co., Remote Monitoring & Diagnostics. (RM&D) by GE, and Hi-Mate by Hyundai. In marine field, there are similar systems as well, such as CBM system by Wärtsilä, FleetViewOnline (FVO) system by Transas, and Maritime-SOL system by Mitsui Engineering & Shipbuilding Co., Ltd. All these system are fleet monitoring and management system, with a unified management center to monitor all important data of the whole fleet, and make decisions to support their customers (Zhan et al., 2005; Stojanovic et al., 2009; Giacobbe et al., 2010; Hess, 2005).

Buoy tender of CWB(Changjiang/Yangtze River Waterway Bureau) is a kind of 30-40 m long small boat used to positioning and maintenance navigation light buoy across the Yangtze River for safe navigation. CWB owns hundreds of tenders scattered across 2000+ km. with GPS, 3G mobile communication and WEB technology, a comprehensive fleet technical management system was developed for all CWB owned vessels, to monitoring real-time operational data, including equipment operational parameters, events and alarms, position and voyage related datum. With these data collected, data can be aggregated, make statistics and comparison ship by ship, sub-organization by sub-organization, to pin-out better operational practices, for a better fleet operation.

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2. System architecture

As a mobile vehicle, ship's position changes continuously, so a mobile communication technology is needed to make it connected with management office. For sea-going ships, satellite communication is the only feasible means today; however it's expensive and provides limited bandwidth, while for ships sail on inland waterway, land based cellular mobile communication networks, such as 3G (WCDDA/CDMA-EVDO/TD-SCDMA), GPRS communication provide lower cost, higher bandwidth, and satisfied coverage for ships on inland waterway (Sorribas et al., 2009; Chen et al., 2010; Mao et al., 2003). Both satellite and 3G communication is not 100 % reliable, technical means have to taken, such as transaction-based data transfer technique, to guarantee the reliable data exchange.
From the perspective of a management staff, there are two mode to access ship data, which are vehicle (ship) centred and office centred.

Table 1 Connected Ship Operation Mode Comparison

Item	Office centred mode	Vehicle centred mode
Server	A single unified server on office for all fleet ships	A server on each ship
Data	Original data on ship, with snapshot and important data copy on center server	All on ship
Application	Unified software Reside on center server	on ship, may be different for different ship
Advantage	Unified software with unified data, a single access point, data statistics possible, better availability	More intense data, rich and diverse functionality,
Disadvantage	Only with data snapshot, almost impossible and with no rational to get every bit of data copy to server.	Data aggregation and statistics almost impossible, function unavailable in cased ship offline

We prefer office centered mode, and a WEB-based fleet technical management center is established, to accept uploaded data from all ships, and provided a single unified WEB application to monitor real-time operational data, and comprehensive data analysis.

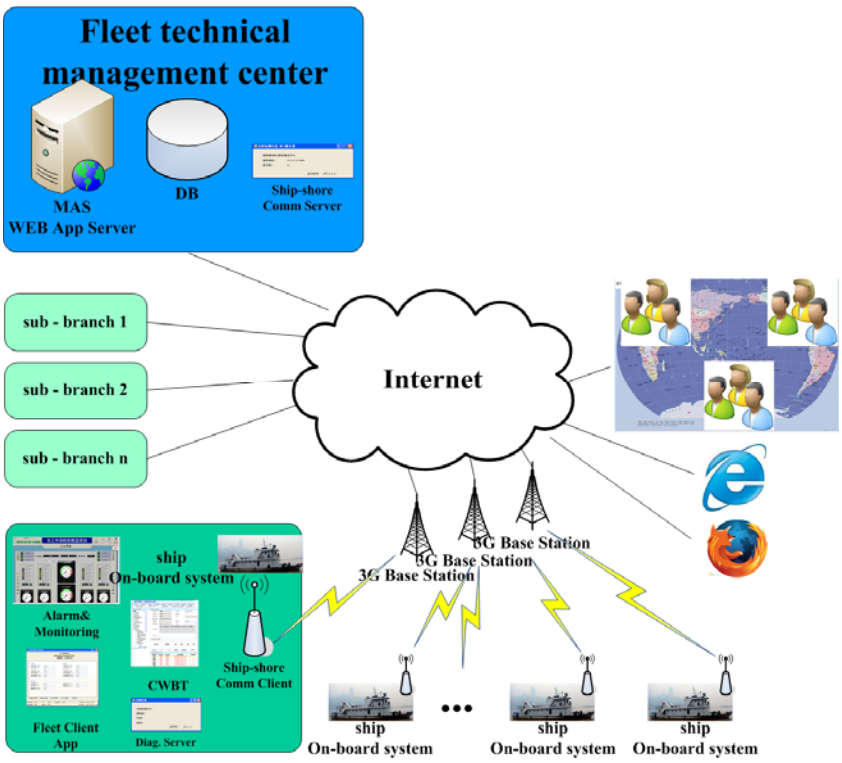

Figure 1 System architecture

Figure 1 is the system architecture we build for inland waterway buoy tender fleet. Each ship is equipped with a 3G terminal, to make them internet-connected. Both the center and ship onboard system are autonomous systems, we also designed a coding and data-exchange standard, every on-board system design should follow these standards, and then can exchange data with center spontaneously.
For a comprehensive fleet management center, the functionality needed are: a single unified application platform to monitor and manage all fleet ships; ship-shore data exchange; real-time operational data remote monitoring; data aggregation, statistics and comparison; operational data replay; operational Knowledge sharing and ship-shore integrated technical management.

3. Ship-shore data exchange

There are many valuable operational data onboard the ship, for all ships in a fleet to upload data to the management center, for these data can be analyzed, like trending, aggregation and statistics by a single application, a coding standard has to be placed there, so we proposed one, as in Table 1. Every measurement data is given a 9 bytes ID in decimal, in “ssuummtss” format, “ss” stands for 2 bytes representing system, “uu” stands for 2 bytes representing sub-system, “mm” stands for 2 bytes representing measurement point, “t” stands for 1 byte representing signal type, “nn” stands for 2 bytes representing system serial no., fuel oil inlet pressure for port(left) side main engine (M.E.) would be 010101101, while fuel oil inlet pressure for port M.E. would be 010101102

Table 2 Operational data coding schema for data exchange

Coding		system	Sub-system	Measurement point	Signal Type		Serial No.
					Name	Code	
length		2	2	2	1		2
Seq.	coding	Main Engine (01)					
1			Fuel System (01)				
2	0101011nn			Inlet pres.(01)	Pres.	1	
3	0101013nn				Low	3	
4	0101021nn			Oil temp. (02)	Temp.	1	
5					Low	3	
6			Lub. Oil System (02)				
7	0102011nn			Oil Pres.(01)	Pres.	1	
8	0102013nn				Low	3	
9	0102015nn				lowlow	5	

For reliable data exchange, we proposed a file-based data exchange schema, that is, onboard the ship, data is packaged into a data file at regular interval, and upload to the management center with FTP protocol. File upload started with a temporary name, to prevent fleet management center to process these transfer-in-progress file, when transfer finished, a normal name will be given, indicate that software in management center can process is safely, while transfer failed, the data file will be saved for future transfer, as shown in Figure 2.

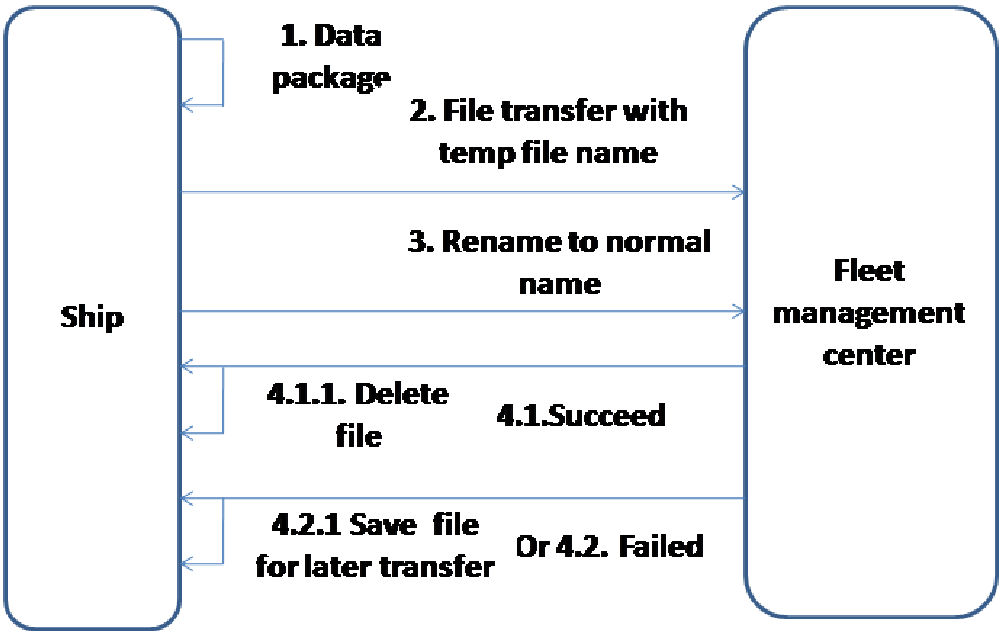

Figure 2 Data exchange transaction

Data file format is in Table 3, this is a general form, for 4 categories of data, which are machinery operation data, alarms, real-time data of job, and statistics of job. Each category of data is further formatted as in Table 4 and Table 5. ID filed in Table 4 and Table 5 is defined in Table 2.

Table 3 data file format

Field name	Data type	Bytes	Description	
File type ID	int	4	Identify file format	
Seq. No	int	4		
Ship ID	int	4		
Data time	long	8		
TAG	short	2	Data sub-ID	
Category	byte	1	Operation 11 , Alarm 12 , Job RT 21 , Job Statistics 22	TLV(tag-length-value)mode, can be mixed
Data length	short	2	Length that following	
Data value	Type related	Type related	Table4, Table5 according to type value	

Table 4 operational data

Field name	Data type	Bytes	Description
ID	int	4	
Date-time	long	8	
Value	double	8	

Table 5 alarm and event

Field name	Data type	Bytes	Description
ID	int	4	
Date-time	long	8	
Value	byte	1	1：Alarm Fire 2：Alarm cancel 3：Alarm Ack

4. The connected digital ship

As most of today's ships have already equipped with computerized alarm and monitoring system, all important equipment operational data have been collected, processed onboard, and the measurement hardware devices have been used by these systems. To further upload these data to management center, onboard data have to be collected and packaged according to pre-defined standard.

For existing ships, a ship-shore data exchange functionality would be realized by an add-on software. This new software will get most of the data from alarm and monitoring system through provided API (application programming interface).

Figure.3 is the onboard software system we developed for data exchange. This software package can access measurement hardware directly, or get data from alarm and monitoring system, and itself can be an alarm and monitoring system.

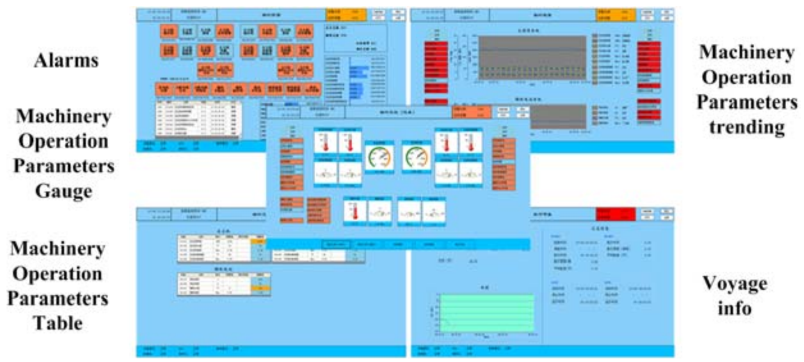

Figure 3 On-board system for alarm, monitoring and data exchange

5. The fleet technical management center

The fleet technical management center is for both real-time operation monitoring and historical data statistics, so we provide 2 database for each purpose, one for fast access latest real-time data, one for large volume historical data.

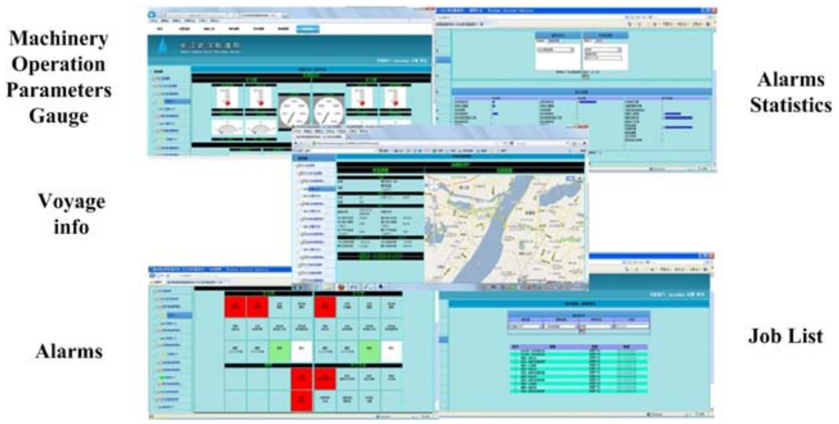

Figure 4 WEB system for fleet management center

The technical management center application is a WEB-based system, so any PC with browser can access it anytime and anywhere. Web system periodically fetches real-time DB data into WEB server application memory through WCF (Windows Communication Framework) Inter-process communication techniques. While for statistics functionality, only we users click a button to initiate an action, data will be fetch from SQL Server by SQL query.Functionality page provided are real-time monitoring of operational data, events and alarms, positions and other voyage related data, as in Figure. 4.

6. Conclusion

An office centered technical management system for a fleet is a useful tool to monitor the whole fleet operation, in real-time, and keep track of their operational history. We propose a WEB-based management center system, related data coding schema, and transaction-style reliable data transfer. With this type of fleet management system, real-time operational status can be monitored, and better operational practice could be pinned-out, to make the fleet operational better.

Acknowledgements

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