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Communications strategies for on-ship CDPC systems

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ABSTRACT

Background: *Individual countries and international organisations have worked on standardising methods for on-ship prevention and control of communicable disease (CDPC). A number of voices have called for integrating the various aspects of maritime CDPC.*

Aim: *The purpose of this article is to further conceptualise the totality of on-ship CDPC activity as an integrated system and to suggest a few strategies for communications in such systems.*

Materials and methods: *The methods used to summarise standardisation and integration of ship-board CDPC procedures included a scientific literature review and a web search. The fields of the review were maritime, health, and technology sources. Special attention was paid to material dealing with communications methods and issues related to ship-board systems and methods to manage communicable diseases.*

Results and conclusions: *Effective communications strategies are vital for the success of CDPC systems. I suggest some specific viewpoints and strategies to improve communications: (i) It is sometimes helpful to view the Constituent Relations Management (CRM) team as a system component. This view highlights the fact that an on-ship CDPC system will be well designed and maintained only if constituent relations are well designed and maintained. (ii) For rapid communications with appropriate groups of constituents, it is important to structure groups of constituents, with the ability to rapidly apply set-theoretic operations to those groups. (iii) Optimistic concurrency control is generally the appropriate general strategy for synchronisation of on-ship CDPC data locations and data storage types. This may be modified in special situations, in particular with a latest-update-wins policy for disease contraction data in an epidemic. (iv) To encourage traveller cooperation with CDPC efforts, cultural activities may be helpful.*

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Key words: on-ship cultural activity, electronic health record, communicable disease prevention and control (CDPC) systems, constituent relations management (CRM), light directory access protocol (LDAP), on-ship CDPC systems, optimistic concurrency control, representational state transfer, traveller cooperation, use case packages

INTRODUCTION

A number of characteristics of travel by ship create special contagious disease risks and treatment difficulties (for a list of such factors, see — among many others [1]). In addition to various maritime environmental and safety issues there are dangers from disease-spreading attempts by malicious groups and individuals.

During the last decades, international cooperation, advances in medical knowledge, technological capabilities for information management, communication, and rapid delivery of supplies have improved the chances for preventing and controlling communicable disease on ship. The U.S. developed the Vessel Sanitation Program in the early 1970s [2]. Cana-

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da initiated its Cruise Ship Inspection Program (CSIP) in 1998 [3]. In 1999 the European Union undertook development of a system for the control and prevention of influenza-like illness on ship [4]. In 2005 the World Health Assembly agreed upon revised World Health Regulations [5], promoting global surveillance and measures to deal with public health emergencies. The EU launched the SHIPSAN Project in 2006 and SHIPSAN TRAINET in 2008 for the purpose of controlling on-ship communicable diseases [6].

Standard procedures and systems for various activities within the field of on-ship communicable disease control and prevention have emerged. Centres for Disease Control [2] and Saginur and Birk [3] give excellent descriptions of these operations. Mouchtouri et al. [7, 8] surveyed on-passenger-ship diseases and inspection practices and systems, and they discussed work on standardisation and internationalisation. However, Rachiotis et al. [9], surveying 21 countries, reported major gaps in disease surveillance among seafarers on passenger ships.

In the past decade, several authors have promoted a more unified systems view. Canals et al. [10], Hasanzadeh et al. [11], and Jaremin [12] emphasise the importance of integration of services and components. Armitage et al. [13] highlight the need for healthcare in general to pursue integrated models and systems: *...It is important for decision makers and planners to choose a set of complementary models, structures, and processes to create an integrated health system that fits the needs of the population across the continuum of care.*

Jensen et al. [14] apply the same thinking specifically to the health of seafarers, pointing out the inefficiencies in the compartmentalised state of various practices. Jerome [1] presented a conceptual-level outline for a distributed multi-ship communicable disease prevention and control (CDPC) system. Here I summarise the concept of an on-ship CDPC system — a concept useful whether or not the ship's management originally conceives of its CDPC activities as a system.

OVERVIEW OF A CDPC SYSTEM

I am describing not a specific system, but a conceptual one. One that incorporates many practices currently employed or employable in on-ship communicable disease prevention and control. Booch et al. [15] provide a good review of — or introduction to — many system design notations and concepts used here (such as use cases and use case packages, context diagrams, technical architecture diagrams).

ACTIVITY CATEGORIES (USE CASE PACKAGES)

Among the first steps to understanding on-ship CDPC systems is to list the categories of such systems' interactions (also-called *use cases*) with constituents (the interaction categories are also referred to as *use case packages*). Here is such a use case package partition:

- **Library access.** Provide fast and reliable access to information (symptoms and syndromes, disease occurrence probabilities and confirmation, prevention and response) about communicable diseases at sea.
- **Manage non-human resources.** Inspect, test, monitor, and repair resources and conditions: environment; infrastructure and equipment supplies and materials; HVAC systems; waste and recycling; manage animals (including pests).
- **Promote human health.** This includes pre-embarkation information gathering, medical examinations, prevention, treatment of on-board occurrences of symptoms, syndromes, diseases and post-disembarkation tracking, treatment, and outcome tracking.
- **Collaborate.** Work with parties outside the current system.
- **Evaluate and Plan***.* Maintain history, evaluate past prevention, and control activity; analyse risks and scenarios, plan future measures and policies.
- **Administrate and maintain system.** Ongoing operation and repair of the current system.
- **Develop new versions of the system.**

CONSTITUENTS

The system's constituents (parties interacting with the system, also called *stakeholders*) are passengers, crew (including the on-ship health and medical team), off-ship personnel, ship company, ship repair/maintenance contractors, ports, other transportation units (e.g. helicopter services), external organisations (medical, maritime, technology, environmental); friends and family; government regulators, suppliers; law enforcement; systems team and external systems and their components. These are the entities that provide/receive services to/from a CDPC system.

CONTEXT DIAGRAM AND THE CONSTITUENT RELATIONS TEAM

For an overview of system activities and constituents, we can now provide a context diagram (Figure 1). Within the large rectangle representing the CDPC system are shown the use case packages. The dia-

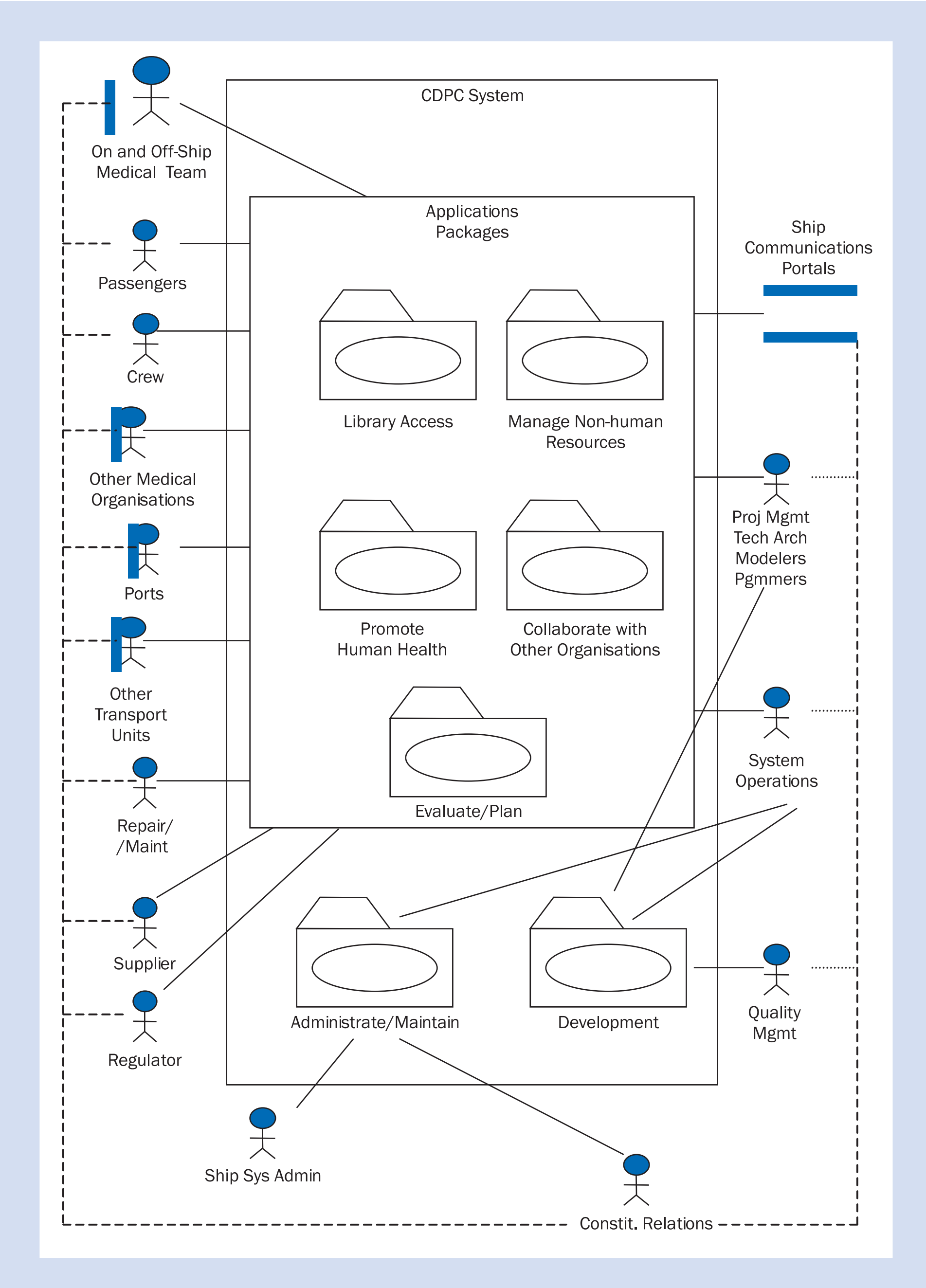

Figure 1. CDCP system context diagram

gram is then a visual summary of the constituents, interactions, and use case packages mentioned.

The constituent relations team as a system component

Developing and maintaining any system require various work teams (≡ *system activity dimensions* ≡ *workflows*). In the context diagram these teams are represented by the person icons on the outside right of the large rectangle.

The constituent relations management (CRM) team has responsibility to:
— communicate with constituents;
— maintain information about constituents and their communications.

There is tremendous variation among communication habits, languages, and media among maritime constituents. Assurance that everyone is mobilised or at least contacted requires an array of communications media and styles. It will help our view of an on-ship CDPC system to expand and contract the large rectangle in the context diagram according to our focus. From one point of view, the CRM team is, as seen in Figure 1, one of the parties interacting with the system. It manages newsletter and website context and maintains records of constituents and their communications. However, when the "system" communicates in non-electronic ways with passengers, crew, government and port authorities, and others, we must view the CRM team as a key component of a CDPC system. The team's communications are the system's communications. This team includes leading communicators from the crew, medical team, and other ship people. For example, the health team's talks and demonstrations on prevention are part of the system. If the team does not relate well to its audiences, the system's functioning will suffer. In short, the system has human components in addition to hardware and software.

TECHNICAL ARCHITECTURE

The architecture for a multi-ship system needs distribution of information, with the ability at an off-ship home base to rapidly analyse occurrences over a whole area. Figure 2 represents a typical architecture for a CDPC system.

Each ship keeps and transmits to home-base records of symptoms, syndromes, test results, diagnoses, and treatments. The home-base system connects to a land-based medical team, to medical libraries, and other information sources. Each ship can receive and convey alerts, as well as obtain probabilities, diagnoses, suggested procedures, and guidance from off-ship medical personnel.

COST/BENEFIT AND FEASIBILITY

Such a system requires commitment to a large-scale operation. Part or all of it may be managed by an individual company, by government, or by a collaborative effort. While the costs and benefits will

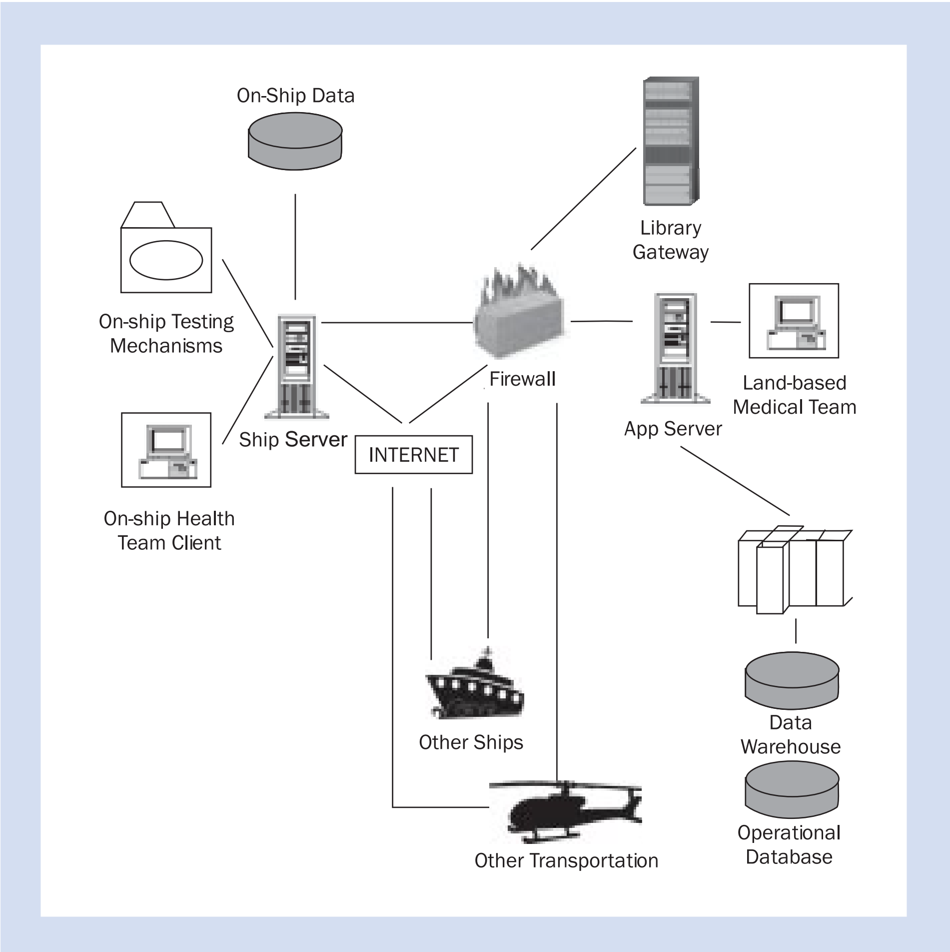

Figure 2. A technical architecture diagram for a CDPC system

depend on the specifics of the implementation, the sources of incremental costs and benefits follow a pattern.

Incremental costs

- System development. This does not stop after the first deployment, but continues through successive versions and releases.
- System maintenance and ongoing evaluation. The system requires responsible people both on individual ships and at central locations. As usual with distributed systems, the relative cost per ship (person, person-kilometre) decreases as the number of ships (persons, person-kilometres) increases, because of economies of scale.
- Educational and cultural activities. These play a key role in assuring prevention and control of accidental or purposeful contagion.

(I have not mentioned costs of health personnel and operations, or of international collaboration, because these costs occur with or without such a system.)

Incremental benefits

- Better organisation and rapid communication of medical knowledge and health-related data speed prevention of, and response to, infectious disease.
- Long-distance medical consultation and treatment avoid many otherwise necessary ship diversions. This is the point stressed by Patel [16].
- Standardisation of procedures enables improved quality of service.
- Technology and a globalised view of disease spread facilitate rapid deployment of appropriate medical methods.

As with costs, the amount of benefit — in both human and financial terms — will be dependent on the scale of the project, and on the extent of collaboration among maritime entities. Ultimately it is the increasing complexity and scale, needs, and capabilities in maritime disease prevention and control that will most likely make mandatory more considered design and implementation of CDPC systems.

COMMUNICATIONS STRATEGIES

An on-ship CDCP system requires heterogeneous communications means for communicating with off-ship constituents. While the Internet and Web are certainly important, we need the panoply of media, including wireless and broadcasting. Among others, Chowdhury et al. [17], Lu [18], Wilson and Brownstein [19], and Lewis et al. [20] discuss resources and options.

While not restricted to either the maritime area or to communicable diseases, Burgess et al. [21] report advances in information delivery by the National Library of Medicine's MedlinePlus Connect Service that are significant for on-ship CDPC systems development. In particular, to clarify and provide electronic health records and medication information, the MedlinePlus Connect system uses a representational state transfer Web service and a Vivisimo search engine. Such creative approaches to hazy and hidden data give promise that CDPC systems can respond well in moments of crisis. Here I suggest some strategies to improve effectiveness.

GROUPS OF CONSTITUENTS FOR SPECIFIC NOTIFICATIONS

Various groups of constituents — often defined ad hoc according to rapidly developing situations — need to be contacted regarding various health prevention and control matters. Example: Ω — on-ship people speaking French; Φ — on-ship people who have been vaccinated against pneumonia; Λ — on-ship people with currently reported upper respiratory symptoms.

Constituent contacts, groups of constituents in an LDAP directory

Effective on-ship communicable disease control requires the ability to quickly set up contact info (once obtained) for constituents, to indicate membership in groups and to send messages to a whole group at a time. A light directory access protocol (LDAP) directory for constituent ID and contact fits this requirement well (Arkills [22] provides an excellent introduction to LDAP). The membership relationship ε defines a directed acyclic graph structure on such groups of constituents:

- one group may be a member of another (e.g. in the example above, it may be that $\Omega \; \varepsilon \; \Phi$).
- for any group Γ, $\Gamma \not\varepsilon \Gamma$.
- for any groups Γ, Δ $\Gamma \; \varepsilon \; \Delta \rightarrow \Delta$ is not a member of Γ or of any membership predecessor of Γ [*predecessor* $\equiv$ member of ...member of Γ].

Set theoretic operations on groups of constituents

For on-ship response to communicable disease threats and outbreaks, it is important to be able to rapidly generate and contact new constituent groups from common set-theoretic operations of union, difference, and intersection of existing groups. For instance, using the example above, we may need to identify and send a message to unvaccinated French speakers with respiratory symptoms, i.e. to $\Omega \cap (\Lambda - \Phi)$. The CDPC system team needs to implement a program for such operations on the constituent LDAP directory. Barton [23] discusses some considerations in programming these operations.

SYNCHRONISATION OF DATA LOCATIONS AND DATA STORAGE TYPES

The amount and types of data that are stored on an individual ship will vary greatly, but will typically include:

- thumbnail contact, communication, and skill-set specs for the ship's constituents (on board and off);
- status and log of ship and surrounding conditions;
- condition and treatment of people on board;
- local version of electronic health record.

These will typically be stored in one or more of:

- LDAP directory;
- relational database;
- other files, such as Unicode text, office software documents, photographs, sound, video, email, programs, books, and journals.

Off-ship data includes all of the items above as well as:

- big data: very large, complex data sets and analyses. Much of this data, or links to it, may be stored in an object database.

How to synchronise these data stores. For CDPC systems, with:

- most of the data non-transactional;
- relatively long takeouts for various data elements, records, and files;
- infrequent update contention

the principle between versions should generally be optimistic concurrency control. A race between updates by authorised parties is won by the one with earliest time stamp. Other updates are then categorised as anachronistic. Notice of the accepted update may be communicated to all parties having taken out anachronous versions, so that those parties may decide how to proceed. Update submissions with anachronous data are blocked, with messages sent to the submitting party.

There are some situations warranting a more restrictive, pessimistic control or, alternatively, a latest-update-wins policy (such a policy can be useful with disease contraction data in an epidemic), or where relationships between on-ship and central server person information are sufficiently complex to need business-rule negotiation of deltas, but the optimistic strategy is most likely to fit in on-ship CDPC systems.

CULTIVATING TRAVELLER COOPERATION

The problem of getting people (both passengers and crew) to follow recommended practices has generally been a trouble spot in controlling on-ship and post-disembarkation diseases. Merson et al. [24] reported that 75% of occurrences of gastroenteritis (as reflected in his questionnaires to passengers) were unreported in ship logs. Centres For Disease Control [2] and Saginur and Birk [3] mention similar problems with regard to sexually transmitted disease. Neri et al. [25] detail various ways people fail to cooperate — from not washing hands to not reporting illness (occurring prior to embarkation or during voyage) to not using hand sanitizer.

To increase cooperation with a CDPC system, the CRM team will need to win hearts and minds, encouraging and educating passengers and crew, keeping track of preferred communications means and languages, responding to people's concerns. Saginur and Birk [3] mention certain individuals on ship whom the passengers will be free to consult, and they suggest provision of counselling. Centres For Disease Control [2] mentions interviews and distribution of newsletters. We need to see this as an ongoing mobilisation: discussions, cultural activities, and contacts from prior to disembarkation all the way to long after disembarkation. The team needs to cultivate communication and artistic events having themes like health, body, and people's lives on ship. In doing this, there is a risk of too much — evoking non-interest or even resentment — as well as of too little. Correctly done, these activities — not narrowly focused, but cultivating traveller creativity — can actually be a draw for passengers and employees, as well as an encouragement for more healthy practices. This work is not easy, but essential. Two examples:

- A shipping line might run a short playwriting contest with the theme: Health On Ship. Accepted contest entries would be performed (either off-book or as staged readings) on ship, with audience feedback. In my own experience as President of Around The Block, a New York City arts and technology organisation, I have seen the tremendous enthusiasm generated by such programs.
- A ship can promote and connect to health-promoting digital games, of the type described by Flanagan et al. [26] and Maiolini et al. [27]. Such games are particularly valuable in reaching adolescents — and through them, the rest of their families.

There may be an objection to this approach. Will discussions about health and appeals to report infection dangers stimulate unwarranted fears, complaints, and rumours? As in all situations calling both for building of strengths and for alertness to threat, there is no pat answer to this question. Much will depend upon the sensitivity of CRM team efforts.

CONCLUSIONS

I have reviewed the structure of CDPC systems, and I have made some suggestions for certain related communications questions:

- For non-automated communications on contagious disease control and prevention, the constituent relations team can be seen as a system component. Thus the performance of an on-ship CDPC system depends upon, among other factors, the quality of human communication.
- It is important to program the generation of new groups obtained from intersection, union, difference, and other set operations on previously established groups — maintained in an LDAP directory.
- Optimistic concurrency control is the principal strategy for maintaining various formats and versions of constituent information, including electronic health records.
- To encourage passenger cooperation with prevention and control procedures, the CRM team should creatively cultivate activities such as theatre and digital games.

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