SESSION 8: Emergency for electricity/ National Infrastructure Protection Plan

议程八：电力(重要基础设施)应急与保障

公共安全集成 IP 通信解决方案

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【摘要】危急中，公共安全服务中的通信保障和数据信息的访问是至关重要的。一些欧盟的项目都跟这个内容有关。在被推荐的研讨会中，U-2010 和继电器项目已经证明了这一点。

U-2010 平台是为普遍的政府、企业 IP 中心可视网络而建。方案主要是想借助于通信手段提供最大容量的、高效的信息访问以满足人们在各类突发事件和危机中的不同需要。这个方案还可用于已有和计划建设中的通信基础设施建设。

继电器平台是为欧洲公共安全异构网络而建的。这个平台的设计构思是要实现满足公共安全需要的多种能力。这些相互作用在同一技术水平（相互作用于不同的无线技术或视频技术间）或一个功能水平（不同部门之间的合作）都发挥着作用。

公共安全集成 IP 通信解决方案研讨会涵盖以下几个主要论题：

1. 介绍 U-2010 和继电器项目方案和地下通道发生火灾的处置脚本
2. EPT 卢森堡项目经验和试验台，教学
3. 在公共防护和救灾中如何有效利用加密无线网

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4. 多元化服务开放式无线宽带设想（网络积木系统）架构来自于第一次加密无线网集成的测试
5. 有智能网接口的专用集群移动通信网 的 IP 集成

【关键词】公共安全通信；加密无线网；试验台；IP 通信

INTEGRATED IP COMMUNICATION SOLUTIONS FOR PUBLIC SAFETY

WORKSHOP ON THE RESULTS OF THE EU-PROJECTS U-2010 & HNPS

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Keywords

Public Safety Communication, Ad-Hoc Networks, Test Bed, IP communication

Abstract

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In a crisis communication and access to data and information, is critical for public safety services. Several EU projects tackle this topic. In this workshop, results from the u-2010[13] and HNPS[14] projects will be presented and discussed.

The u-2010 project's objective was to provide the most capable means of communication to everybody required to act in case of accident, catastrophe or crisis, as well as the most effective access to that information,. The project aimed to use any existing or (future) planned communication infrastructure to do this.

The HNPS project's purpose is to design and implement interaction capacities for important public safety applications. These may be at a technical level (interaction between different radio technologies or different video applications) or at a functional level (the collaboration between different agencies).

The Workshop

"Integrated IP Communication Solutions for Public Safety" presents the u-2010 project's emergency communication solutions, illustrated with the "Fire in a Tunnel" scenario, as well discussing the first achievements of the HNPS project.

Five of the projects' partners will speak about the following topics:

- An introduction to the u-2010 and HNPS project and to the "Fire in the Tunnel" scenario
- The EPT Luxembourg (Telco) experience, building a test bed for public safety; lessons learnt
- Deploying ad-hoc communication in PPDR
- The architecture of a multi-service deployable Wireless Broadband Bubble (W3B) including results from the first integration tests of HNPS
- IP integration of PMR with the On-Demand Intelligent Network Interface

Introduction

Recent catastrophes such as Hurricane Katrina (September, 2005), the earthquakes in Haiti (2009) and more recently in China (2010), dramatically show the importance of communication in preventing the deaths of thousands of people.

Effective communication and access to information is a key requirement in crises. In New Orleans and Haiti especially nearly all communication broke down, with several days needed to re-establish effective links. Without communication an assessment of the situation is not possible, and it follows that the coordination of aid becomes very difficult. Having a readily available and flexible communication network would have helped the rescue teams that came from all over the world, to support each other more effectively.

However, one does not require a large catastrophe to make clear the need for improvements in emergency communication. This is true even in countries with a high coverage of modern communication networks.

In Luxembourg, a small country located at the heart of Europe, the national Telecommunications body[15] conducted a study in the years 2003/2004 to analyse the availability of means of communication in the case of a disaster. It was a" paper exercise" that simulated the rupture of a water reservoir in the North of Luxembourg.

The analysis of the resultant communication problems was the impetus for a research project under the 5th call of the 6th framework program of the European Union called "u-2010. The goal of the u-2010 project

[13] ubiquitous IP-centric Government & Enterprise Next generation Networks Vision 2010
[14] Heterogeneous Networks for European Public Safety
[15] La Comité Nationale de Télécommunications (CONATEL)

was to provide new concepts for communication solutions for emergency services. The u-2010 project started in May 2006 with 16 international partners.

The project developed prototypes and solutions based on IPv6 technology. It also implemented basic prototypes for network mobility (NEMO), mobile ad-hoc networks (MANET) and wireless sensor networks. Based on these network technologies the project developed solutions that allowed the emergency services to access the information they needed in their headquarters as well as on site.

The project proved that its tasks had been successfully accomplished in a comprehensive public demonstration, made at a tunnel in Luxembourg on the 22nd of October 2009, which simulated a "fire in a tunnel" scenario. The feedback from the Civil Protection, who also participated in the demonstration and from the audience, was very positive, and furthermore, the interest in the demonstrated technologies was very high.

However, during the u-2010 project's working lifetime it became clear that the project could not cover all the aspects of communication interworking and information access. New technologies were emerging and existing technologies were being combined to provide new solutions to existing problems. WiMAX, mobile WiMAX, LTE and Tetra are examples of changing network technologies that might extend the u-2010 integration for public safety solutions.

Therefore a new project, dealing with public safety communication and called "Heterogeneous Networks for Public Safety" (HNPS), was started in November 2008. 14 partners from Luxembourg, France and Spain are cooperating on this project. The goal of this project is to enhance the solutions created in u-2010 and to add new technologies.

U-2010 - Overview of the "Fire in a Tunnel" Scenario (and Demonstration)

The u-2010 project was given permission from the Luxembourg Ministry of Public Works to use a section of one tube of a highway tunnel that was still under construction. It is a modern two tube tunnel with a length of three kilometres.

A scenario was played out which simulated a car accident, followed by a fire, in one of the tubes, one and a half kilometres from the entrance. Existing emergency procedures were carried out as if in a real event. The scenario used the new communication technologies developed within the u-2010 project. Members of the Luxembourg Civil Protection and the Luxembourg Police also participated in this demonstration.

<u>The "Fire in a Tunnel" scenario in more detail:</u>

A car accident happens in the northern tube of the highway tunnel "Grouft" A fire breaks out.

The emergency centre 112 is alerted by exceeded thresholds for smoke and CO concentration which are monitored by fixed sensors inside the tunnel. 112 checks what happened via video cameras and alerts the civil protection and the police using the u-2010 alarming tool AlarmTilt.

The volunteers of the civil protection respond to the alert and hurry to the fire station. Thanks to the u-2010 localisation solution the commander can track the location of his team members and assess when his team will be complete to leave the station with a mobile command vehicle and a fire engine.

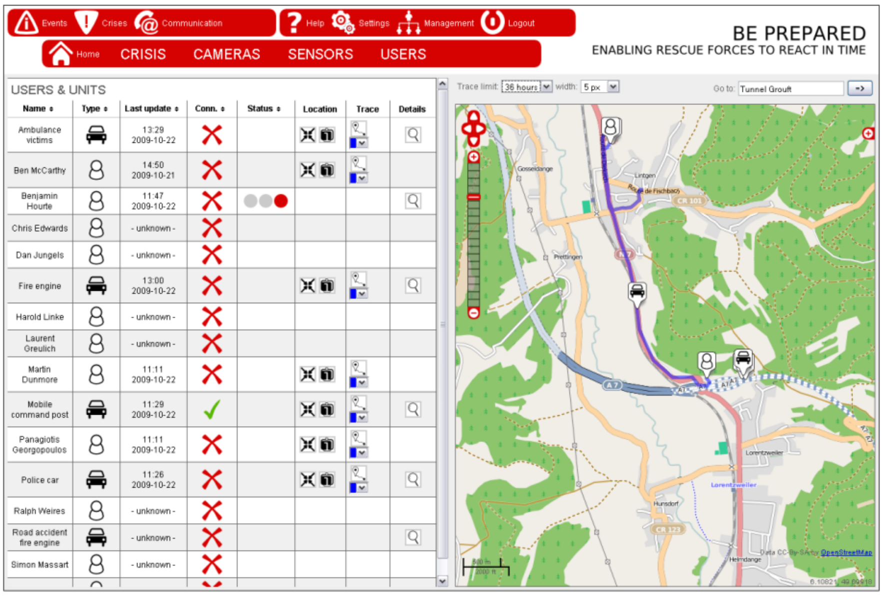
While on the move to the tunnel, the commander and Headquarters can monitor the video cameras and sensors inside the tunnel using a specially developed application; The Headquarters Service Portal, which is a web application, and which is available on redundant servers and is connected to a specific middleware. It allows access to several functions:

- Localisation
- Integration of various types of sensor data
- Video Streaming

It allows the operators to assess the situation in the tunnel by monitoring the sensor values of the fixed sensors and to access the video cameras in the tunnel. The portal also allows the operators to follow the approach of the mobile command post on a map and to access the video camera located in the mobile command post.

The rescue forces' trip to the incident site can be monitored in the portal, The following portal screenshot shows rescue forces on their way to the tunnel. In addition to showing the most recent location of all units, the small blue trace line shows the elapsed journey of a selected unit that has already arrived on site.

Figure 1: Users view of rescue forces on their way to the tunnel



On its approach the mobile command vehicle, with the commander, stops at the tunnel entrance and sets up a Mobile Command Post. To improve the connectivity to Headquarters a Nomadic Satellite Communication System is set up.

The Mobile Command Post stayed at the tunnel entrance, see

Figure 2, It provided WAN[16] access to an off-site Fixed Crisis Centre and set up a broadband Incident Area Network (IAN) that shared the WAN.

An additional engine, Fire Engine 1, entered the rescue tube and stopped in front of Gallery 7 (just before the accident site) following the smoke evacuation plans.

The fire engine was connected to the Mobile Command Post via a broadband ad-hoc network, making up an Incident Area Network. This connection allowed the transmission of live video from the fire engine to the mobile command post.

Figure 2: Positions of Network Components in Tunnel Scenario

[16] Wide Area Network

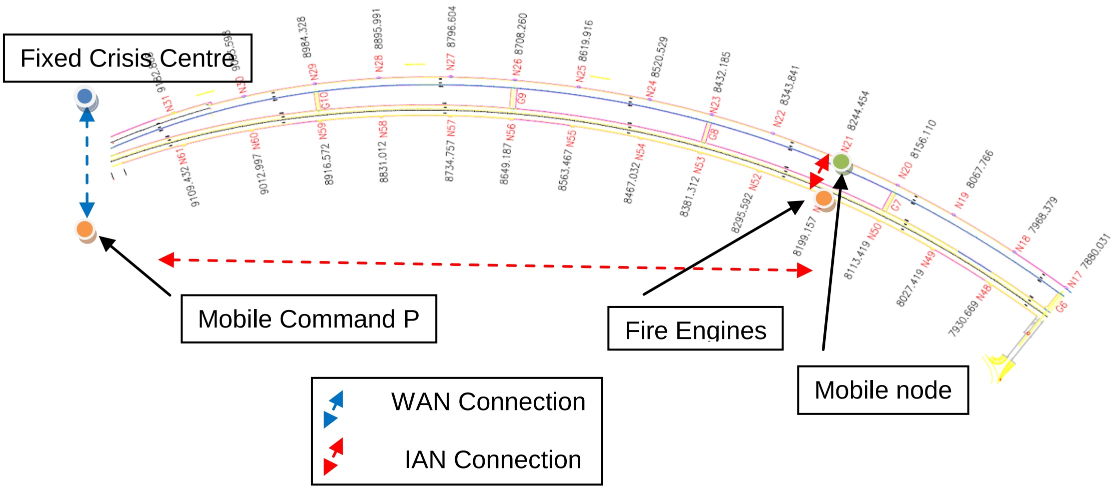
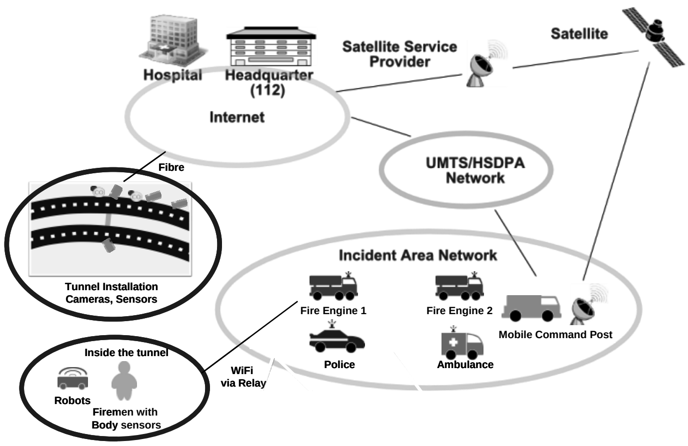


Figure 3 shows the general scenario concept used for the demonstration.

Figure 3: General Communication Concept



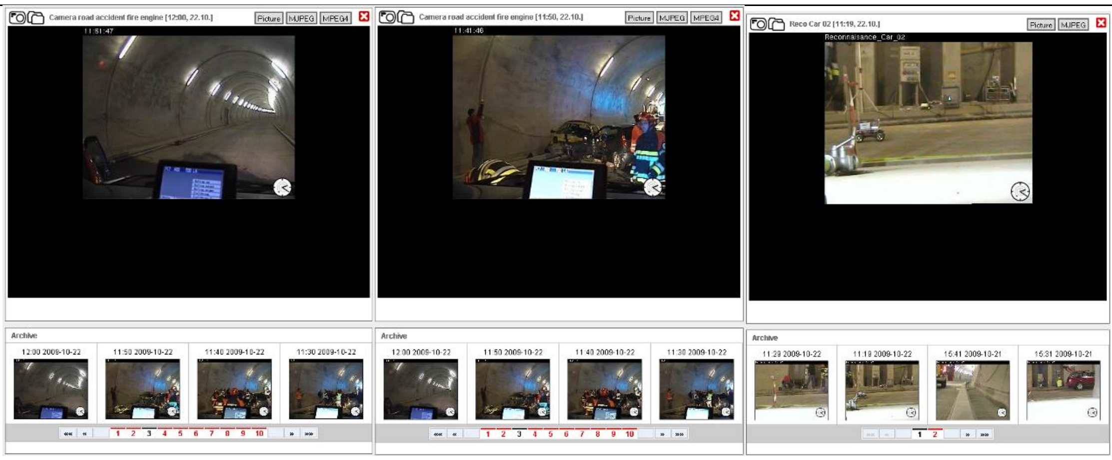
Two fire men with breathing apparatus entered the tunnel via the gallery. They carried a mobile node of the Incident Area Network, to establish a communication link between the tunnel's two tubes. This link allowed video transmission from the accident tube to the Mobile Command Post via the fire engine in the tunnel.

The firemen used two remote controlled robots equipped with video cameras to transmit pictures via Wi-Fi to a mobile node and from there to the Mobile Command Post. The commander could monitor the video directly on his mobile client.

The central point of this concept was the Incident Area Network which connected the involved entities on-site. It provided a broadband connection offering 2 Mb of bandwidth. This network allowed voice and video transmission.

The following pictures show detailed views from car cameras while the rescue forces are in vicinity of the tunnel, are entering it, are executing their rescue mission and are using the robots.

Figure 4: Visual information from different cameras during the rescue phase



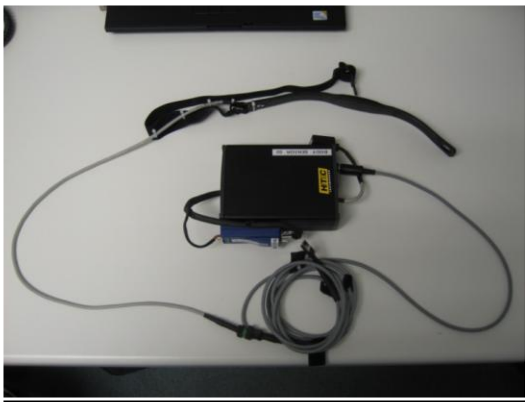
The two firemen are equipped with body sensors and foot sensors that allow the commander to monitor the vital signs of his team members.

These body sensors have been designed to monitor the health of either the first responders or victims. Their function is shown in the table below;

Probes measure:	Sensors can transmit:
Heart beat, Body temperature (contact temperature), Foot pressure.	The heart rhythm, The body temperature, The number of steps.

The system is composed of several components:

Figure 5: Body Sensor overview and Integration into the uniform



Temperature probe	Transmitter module
Heart beat detector	ADC and Bluetooth transmitter
Heart beat receiver	Foot sensor connector

The values can be displayed by the portal or the mobile client.

The information send by the body sensors was very interesting to the commander, as he could assess the condition of his team much better than before.

After the reconnaissance and assessment of the situation the fire was extinguished. In the meantime the police, a third fire engine and an ambulance arrived on site. The police closed the highway and secured the way for the emergency services.

The unique approach in this scenario is that three voice communication systems are used on site: Voice over IP in the tunnel, TETRA for the police and analogue radio for the 3rd fire engine. The u-2010 solution allows integrating all three into one group call and a synchronisation between the different entities.

The arriving services were automatically integrated in the Incident Area Network. Furthermore, they were also integrated into a group call that allowed all the entities to communicate independently from their own technologies and systems.

As soon as the police acknowledged that the tunnel was completely blocked to traffic and the fire men in the tunnel reported that the fire was extinguished, the commander sends the third fire engine and the ambulance into the tunnel to rescue the victims.

The victims were transferred to the ambulance. Video cameras inside the ambulance and body sensors attached to the victims allowed a doctor at a remote hospital to monitor the victims and to give advice to the ambulance team.

Technically the Incident Area Network used in the demonstration was based on network mobility and mobile ad-hoc networks. These technologies are explained in brief in the next chapters.

Network Mobility (NEMO)

Network Mobility (NEMO) functionality was based on a Cisco Mobile Access Router (Cisco 3230) and on a Home Agent. Its role was to provide continuous access to the information centre whatever global network was used (e.g. GPRS/UMTS/HSDPA, Wi-Fi, Satellite, Ethernet…). This continuity of communication allowed applications (clients and server) to work without interruption when switching between the networks.

In the demonstration scenario NEMO was used to give the Commander access to video and sensor information whilst the Mobile Command Post was on the move to the accident. This allowed him to assess the situation before the teams arrived at the tunnel. In the presentation of the final demo we used the NEMO connection to the Mobile Command Post to show live video while the vehicle was approaching the tunnel area.

Mobile Ad-Hoc Networks (MANET)

The mobile ad-hoc network concept creates a new communication network without any specialised configuration in a situation without an existing infrastructure, or in situations where the existing infrastructure is destroyed or overloaded. Typically it consists of one or more mobile routers, placed for instance in cars, helicopters, or even in bags etc. They interconnect automatically to establish a local high performance communication network. This network can then be used by many end devices and applications via standardised wired and wireless interfaces. The transmission of signalling and user data is protected by strong encryption mechanisms.

The ad-hoc network solution is based on the HiMoNN ad-hoc routers developed by IABG. A typical range between two of these routers is around one to two kilometres depending on the topology of the site. For data transmission over higher distances, the router can also be used as a relay node, thereby bridging distance of n times one to two kilometres.

In the demonstration scenario the MANET was used to set up the Incident Area Network. One node was placed in the Mobile Command Post at the entrance of the tunnel, another one in the Fire Engine 1 at Gallery 7 near to the accident. The firemen in the accident tube used a backpack router to provide coverage within this tube. The coverage was very good and it was possible to transmit voice, video and sensor data with no problems.

The Luxembourg Test Bed

The prototype solution of the fire service scenario runs on a Luxembourg Test Bed. All communication facilities are connected to this test which is built around an MPLS IPv6 network that connects different sites in Luxembourg and is operated by EPT Luxembourg. The creation of the test bed provided an excellent permanent trial base that allowed global tests of different technologies and services. It facilitated the tests phases of the Fire Service Solution.

Three main sites were used for the creation of the network; the main hosting centre for the main servers and the link to PSTN and GSM networks, a secondary hosting site for the backup servers with the local DNS, network monitoring and the video encoding and streaming and a third site for peering, satellite connections and broking services. This third site makes the connection from non-native IPv6 connections.

Feedback from the "Fire in Tunnel" demonstration

The users from the Luxembourg Civil Protection who used the u-2010 solutions in the demonstration provided the following feedback:

It was interesting for the Civil Protection to see that the technology can really perform. They were impressed that the promises made about effective, innovative infrastructures and communication technologies were fulfilled.

The firemen asked if it was possible to receive video transmission inside the tunnel or accident site. Specifically the video images captured inside the tunnel would have been of great interest not only outside the tunnel in the Mobile Command Post but also to the teams inside the tunnel.

The firemen were astonished and grateful that the new technology did not hinder them doing their work as has happened before in trials of new technology. The applications were really easy to use and to understand. The remote controlling and monitoring of cameras was appreciated as really useful and good implemented.

They felt the scenario was realistic and reflected the way they worked accurately. A major difference between the demonstration and the reality was the timing; in reality everything is done faster.

According to their evaluation the Portal would be mostly used in Headquarters and in Mobile Crisis Command Centers. The Mobile Client would be used by the Commander of the operation. It should be also installed in every car which might be used by a Commander.

One problem that the Civil Protection saw was that the equipment (prototypes used in the demonstration) was too large and space consuming for day-to-day use. For real scenarios this should be much smaller and more robust.

Security and privacy is another issue that has to be handled very carefully. I.e. the volunteer has to switch on his localization device by himself, when he is on duty. The access rights are managed with a directory service.

The HNPS Project

A new project, called "Heterogeneous Networks for Public Safety" (HNPS), was started in November 2008 to continue the work of u-2010 and to integrate the technologies that came out during u-2010's timeline, such as WiMAX, mobile WiMAX, LTE and Tetra. Fourteen partners from Luxembourg, France and Spain cooperate in this project: In the following pages we explain HNPS in more detail.

IP Integration of PMR

Virtually all network solutions for professional mobile communications are based on proprietary system architectures. Although the air interface may be compliant with open standards such as TETRA, internal interfaces are not. End-users requiring seamless nationwide coverage cannot use equipment from multiple suppliers and therefore have to depend on a single supplier for all TETRA requirements. This "vendor lock-in" unfortunately prevents system expansion, interworking between networks and migration to newer technologies.

The HNPS project conducts research to remove the barriers of closed system architectures. This means interoperability between PMR systems, including TETRA networks, on the basis of open standards. One part of the HNPS solution is the On-Demand Intelligent Network Interface (ODINI) that has been developed in close cooperation with end-users and independent system integrators.

Architecture of a Multi-Service Deployable Wireless Broadband Bubble (W3B)

The HNPS project is developing architectures that may be used to host voice, video and data services in a Wireless Broadband Bubble (W3B).

The W3B based on WiMAX or LTE, offers Point to Multipoint communication for end user equipment only. HNPS proposes a solution to dynamically interconnect several W3B in order to extend the coverage of the bubbles and to offer seamless interoperation between several public safety operators. The dynamics covers the radio configuration and the IP routing with QoS and allows a zero touch configuration of the system on the field. This W3B solution may be used in a crisis to set up communication networks where no communication has been previously available.

The HNPS project made some test sessions to cover several possible conditions of deployment in a highway tunnel in Luxembourg, in order to gain first-hand experience with high frequency wave propagation, signal strength, and available throughput in difficult HF situations. A WiMAX base station was set up in front of the tunnel and inside various client devices (CPEs) were used at various locations to provide values from both tubes.

Basic network functionalities were tested (raw throughput measurements) and the point of coverage loss was determined. In a second session different applications were used to validate the quality of the connection in a real life application scenario. The results of these tests will be discussed in the workshop.

Computer Vision-Based Alarm Detection System

Recent advances in Computer Vision have shown the capability of Automatic Incident Detection (AID) systems, integrated into control centres, to improve decision and response-cycle times in emergencies. Based on predefined user requirements, a Computer Vision based system can be used, not only to access signals coming from various cameras deployed along an infrastructure (which is a basic functionality offered by any video service), but also to centralise and process those video streams in order to detect incidents that may have occurred in the areas under video surveillance.

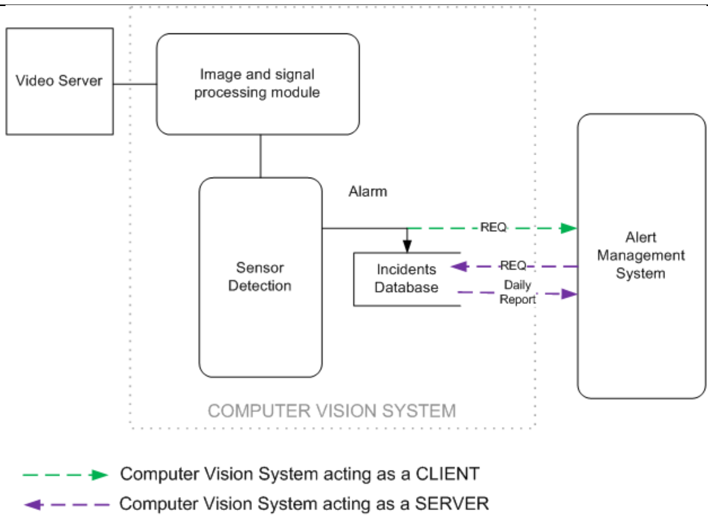
A broad set of scenarios in the field of Intelligent Transportation Systems may benefit from the development of different algorithms that detect, classify and track different objects present in any scene, and more interestingly, the events (abnormal or not) in which these objects may be involved. However, a problem still exists with the solutions, currently used in control centres, since the communication of an alarm to the corresponding entity relies on one operator only who is trained to follow an established emergency procedure. Without wishing to disregard the important role played by the operators in control centres, the proposed system aims to facilitate their work at different levels.

In the HNPS project, software will be developed, where incoming images will be analysed and once an abnormal behaviour has been detected, corresponding alarm messages will be sent asynchronously to an Alert Management System. This alert management system will process the provided information and continue to assess the situation automatically, until the incidents are resolved.

From a practical point of view, the video server, to which the HNPS developed Computer Vision system will be connected, will be available within the audiovisual network of the SGI operating environment, inside the Public Transport Management Centre (PTMC) in Madrid (Spain).

Figure: 6 shows the proposed HNPS solution.

Figure: 6 Proposed Computer Vision-based alarm detection system



Conclusion

The "Integrated IP Communication Solutions for Public Safety" Workshop gives an overview of the u-2010 and HNPS projects. It explains the shared goals of the two projects. It references scenarios from the two projects to either prove the project's success or to explain on-going aims, and some of the projects' partners speak about their project experiences.

Author Biographies

Harold Linke is the Head of the Software Engineering and ICT-Development Department of HITEC Luxembourg. He started his career after studying electronics in Munich at Siemens Germany as a software developer for communication systems. In 2004 Harold joined HITEC Luxembourg, where he is responsible for Software and ICT development. Harold is very active in EU-projects and was the technical coordinator of the u-2010 project and is the coordinator of the HNPS project.

Kate Yeadon is a senior Project Manager at EPT Luxembourg. She has a strong Telecommunications / project background and has worked in various projects and Telcos around the world, before joining EPT Luxembourg in 1994. She is a founding member of EPT's new department "Service des Projets et Dossiers Stratégiques" and is currently working on EU sponsored Emergency communications projects.

Philippe Bereski joined Alcatel-Lucent in 1994. He held several positions in Research and Development, then in Research and Innovation, before leading the "Defence and Public Safety" laboratory of Alcatel-Lucent, in Villarceaux, France. This laboratory is responsible for the definition of new system solutions for this vertical market, based on Alcatel-Lucent of the shelves equipment. Philippe is involved in several national and European research projects such as 6DISS, SEINIT (IST), SIC (SYSTEM@TIC). Philippe is co-author of the book "IPv6 théorie et pratique".

Bert Bouwers joined Rohill in 1986, and was Chief Technology Officer from 2008. He manages a team of highly skilled engineers working on all aspects of trunked radio systems. Bert established the TetraNode system architecture at the early stages of the development, and has continued to adapt the architecture and design of TetraNode according the latest trends in the IP networking industry. Rohill has a reputation for delivering innovative and adaptable solutions. Bert has a profound knowledge of the TETRA standard and has delivered a number of presentations on the subjects of TETRA-over-IP, multi-protocol solutions and Softswitching Technology.

Wolfgang Fritsche received his Diploma in Electric Engineering from the Technical University of Munich and currently is the head of IABG's Internet Competence Centre. Wolfgang has been responsible for several national and international projects and some of his recent activities include consulting to the Federal Ministry of the Interior of the Federal Republic of Germany in the area of Public Safety Communication, leading the

ESA studies on “Programmable Active Networks for Next Generation Multimedia Services” and “IPv6 over satellite”. He leads IABG’s development of the ad-hoc networking solution Highly Mobile Network Node (HiMoNN) and coordinates its sales activities. Wolfgang represents IABG as a founding member in the Global IPv6-Forum and the German IPv6 Council.

Nuria Sánchez is a Telecom Engineer (with honours) by E.T.S.I. Telecomunicación (Universidad Politécnica de Madrid, Spain). Since 2005 she has been heavily involved in several R&D National and European Projects in relation to Intelligent Transport Systems, Safety and Audiovisual technologies. From 2008 on she has been participating in the CELTIC initiative HNPS "Heterogeneous network for European public safety" as one of the UPM Technical Managers. Her professional interests include image and digital video processing, remote sensing, Computer Vision and intelligent systems, mainly focused on human behaviour and scene understanding for video surveillance applications (video interpretation, spatiotemporal reasoning and event recognition mainly).

基于信息技术的特殊需求群体减灾效果研究

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【摘要】本文探讨了利用信息技术解决特殊需求群体在资源方面的需求规划和应对问题。最近的应急事件和自然灾害都表明，对于高危人群在这方面应该做好更好的准备和规划。虽然关于特殊需求的定义各方有所不同，但残疾人士、智障人士、以及患有慢性疾病和语言障碍的人应包括在内。针对这些情况，信息技术作为一种工具能协助应急管理和计划人员为这些特殊需求群体提供更好的服务。本文基于一些案例，为地方级、州级和国家级的应急管理人员提出一种新方法，即利用信息技术系统更好地管理特殊需求群体。信息技术的研究包括关系数据库、人机界面设计、网络应用、通讯路径、以及安全程序和方法。该项技术应用的关键点包括复杂的报告选项、数据可视化、地理空间信息、数据管理、用户群模式、社区伙伴、机构间的兼容性、访问控制和数据的可移植性等。所有这些功能结合起来，可为应急管理人员创建一个有效的工具，协助特殊需求群体做好应急情况下的准备、响应、恢复和缓解。

2004 和 2005 年的综合性风暴季节也许是佛罗里达州居民有史以来遭受的最为痛苦难忘的事情。除了让撤离家园的数百万人避开纵横交错的风暴路径，还要尽最大努力保护那些最脆弱的群体。即使在平时风和日丽时，佛罗里达州医院的床位使用率就能达到 80-90%，这与佛罗里达州的人口特征有关。佛罗里达州作为退休目的地，近 30%的人口都是 65 岁及以上的老年人。这些老年人群除了逐年有小比例增长外还都有不同程度的健康或残疾问题，在热带风暴事件中给公共卫生官员和应急管理人员带来了前所未有的挑战。这些人中大多数都有特殊需求，他们只能在医疗保健人员和现代科技的有限帮助下在自己家中生活。但是，当他们得不到援助或者由于热带风暴导致服务中断时，很多人就面临着生命危险。在 2004/2005 年的暴风雨季节中，如何转移这些重要的特殊需求群体（PSN）、为他们提供避难所和医疗保健服务就成为一个考验。当地很多管辖区域发现自己尚未准备好或者由于装备不良，无法应对在暴风中撤离的有着医疗保健需求的大量人群。佛罗里达州曾经一度因这些特殊需求群体而不堪重负，后来他们开始采取行动，制定后勤计划，在一个能容纳 2 万人的会议中心设立大型避难场所安置特殊需求群体。事后看来，促成该行动的严峻形势是由于迄今以来特需避难所（SPNS）为特殊需求群体所提供的有限医疗保健服务在注册和计划方面还有所欠缺。尽管佛罗里达州没有发生过由于缺乏计划而导致人员死亡的事件，但在卡特里娜飓风中明显暴露出由于缺乏准备导致的悲惨结果，一些医院病人和退休疗养院居民由于被遗弃遭受了可怕的苦难，甚至造成许多人死亡，这些众人皆知的例子都说明特殊需求群体和特需避难所计划急需改进完善。

结论：应急管理机构可以通过设计和运用信息技术系统改进为特殊需求群体提供的服务。这些系统应该易于使用和维护，并能改进数据收集和维护，从而减少工作量。

【关键词】特殊需求；信息技术；撤离计划；避难所；特殊需求注册

INFORMATION TECHNOLOGY AS A TOOL TO MITIGATE DISASTER EFFECTS ON SPECIAL NEEDS POPULATIONS

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Abstract

This paper examines the usage of information technology to address the resource intensive task of planning for and responding to the needs of persons with Special Needs. Recent emergencies and disasters have illustrated the need for better preparation and planning in regards to this at risk population. The definition of Special Needs varies, but can include the physically or mentally disabled, people with chronic illness, or language barriers. In all of these situations, information technology tools can assist emergency managers and planners in providing better services to this population segment. The paper examines several use cases, and presents a path for local, state, and national emergency managers to utilize information 17technology

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systems to better manage Special Needs populations. The areas of technology examined include relational databases; human interface design; web applications; communications paths; and security routines and methodology. Key points of the technology use cases include complex reporting options, data visualization, geospatial information, data management, workload distribution, community partnerships, inter-agency compatibility, access control, and data portability. All of these features combine to create and effective tool for emergency managers to assist Special Needs populations in preparedness, response, recovery and mitigation.

The combined tropical seasons of 2004 and 2005 were perhaps the most traumatic ever suffered by the citizens of the State of Florida. In addition to the millions that evacuated their homes to avoid the crisscrossing storm paths, a monumental effort was put forth to protect the most vulnerable of the population. Even when skies are blue, Florida hospitals experience an 80% to 90% bed capacity, due in part to the state’s demographics. As a retirement destination, nearly 30% of Florida’s population is 65 years of age or older. This senior population, along with a small but growing portion of the residents with varying degrees of health problems or disabilities, presented an unprecedented challenge to public health officials and emergency managers during tropical events. Many of these persons with “special needs” can live at home with limited assistance by healthcare professionals and modern technology. But when these services are not available or denied by interruptions due to tropical systems, many lives can be at risk. How to move, shelter and provide healthcare services for a significant part of the populace defined as “persons with special needs” (PSN) became a trial by fire during the 2004/2005 hurricane seasons.

Many local jurisdictions found themselves unprepared for or ill-equipped to deal with the unanticipated numbers of storm evacuees with healthcare needs. A one point, the State of Florida was so overwhelmed with PSN’s they began operations and logistical planning to opening a super-shelter in a conference center with the potential to house as many as 20,000 PSN’s. In hindsight, the desperate situations that drove these actions were attributed to what to date had been a lack-luster effort at registering and planning for providing limited healthcare services at “special needs shelters” (SpNS) for PSN’s. Although loss of life was not experienced in Florida due to inadequate planning, the tragic results of being unprepared were all too obvious in Hurricane Katrina. A few notorious examples of abandoned hospital patients and retirement/nursing home residents resulting in terrible suffering and many deaths only served to reinforce the need to improve upon PSN and SpNS programs.

Thesis

Emergency Management agencies can improve the service to persons with special needs by designing and utilizing custom information technology systems. These systems should be easy to use, easy to maintain, improve data collection and maintenance, and reduce workloads.

Application

In 2006, the Florida Department of Health, charged with oversight and governance over all public health related issues in the state, commissioned the design, development and performance of a series of tabletop

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exercises to examine PSN programs. These exercises, conducted around a hurricane scenario, were attended by both for local and state government and healthcare officials to gain information about a number of objectives. The resulting After Action Report / Improvement Plan (AAR/IP) captured a number of lessons and continuing challenges faced by local jurisdictions and their PSN programs.

Defining Persons with Special Needs Programs

Perhaps the most essential area examined during the tabletop exercises were those defining exactly what a PSN program should be. In addition to a nationwide ambiguity on exactly what a PSN is, there were questions about evaluating PSN’s and timely, effective communications with PSN’s once registered in a program.

Common wisdom would suggest a single national definition of a PSN would bring order to some of the chaos. To date the opposite has proven true. Each jurisdiction’s demographic, their capabilities for supporting PSN’s during disasters and even local social attitudes all shape distinctly individual community definitions of persons with special needs. Any programmatic solution to this issue must remain flexible enough to encompass this diversity.

Once a local definition is established, then that delineation may be used to decide who is sufficiently in need to be included in the program. Unfortunately, past experiences have shown that many persons who would not meet a majority of defined PSN program criteria sign up because they know that special needs shelters provide a higher level of comfort than general population shelters. It became obvious that a patient triage process was necessary for PSN candidates before being allowed to formally register within the program.

Previously, when persons were allowed to register as participants in a PSN program, there were varying levels of details records gathered and revised. Some registries used standard database software applications while others (if records were kept at all) used paper files and, in some cases, small index cards to track registrants. At best these practices could be viewed as mildly efficient, but a majority of program registries contained insufficient and out-dated information to adequately care for registrants. To compound this situation, little if any resources have been devoted to updating information, so much so that registries are full of deceased registrants or those who no longer lived in the jurisdiction. Even if some personnel or other resources are used, little attention has been given to how this information is used, standard reports or those sorted by individual information elements.

To solve this dilemma requires active participation of the registrant for their own care and safety. A recent draft of special needs program guidance from the U.S. Federal Emergency Management Agency (FEMA) stressed that PSN registrants must take an active part in ensuring their information is updated regularly, that they can receive instructions through the communications channels available and act upon the instructions given. Fortunately, most persons with special needs, contrary to popular belief, have a heightened sense of independence but require an education process so that they know the expectations that the program has for them. Key to this concept was the idea that registrants themselves could assist in registration and updating of their own information. Additionally, a workable program must be able to communicate, through whatever means is accessible to registrants, including voice and text. (Center for Disaster Risk Policy, 2006)

Special Needs Shelter Coordination

When a community finds itself needing to open a special needs shelter to care for persons with special needs, rarely does government, volunteer or even over-stretched private healthcare institutions have the resources or personnel to staff or equip these facilities. So when PSN's arrive, the facility lacks the necessities to care for their needs. As the U.S. National Incident Management System (NIMS) Resource Management schema dictates, local governments may request these resources of state government, who in turn, could forward the request to the federal government should they not possess the needed assets. What the tabletop exercises pointed out was that resource planning was an essential part of PSN program effectiveness. Proper PSN planning should be able to identify the specific medical resources needed by each program registrant and consequently a comprehensive list of clinical resources needed. In standard resource management methodology, if you know what is needed, you should then be able to find locally what is available, and therefore pre-identify resources that need to be requested from other sources. Ignored in the resource management process are those assets owned by the program registrants themselves. PSN's very often own portable versions of the very equipment that allows them a home life existence. If when registering, registrants could list self owned equipment they could bring to a SpNS, those would be resources that would not have to be provided by government. Additionally, many PSN's have in home caregivers. If designated caregivers could accompany registrants to the shelter, this could alleviate the need for government provided or volunteer caregivers/clinicians.

Transportation of PSN's to an activated SpNS has proven to be a difficult planning issue for local and state governments. Many PSN's are dependent on locally provided ambulances or specially equipped vehicles for their limited transportation needs. PSN's need these same transportation assets, or supplemental transportation, normally provided by school buses, for travel to special needs shelters. An optimal PSN program would coordinate this transportation to allow for the afore mentioned self-owned resources, personalcaregivers and even accompanying service animals.

As the 2004-2005 Atlantic hurricane season illustrated, large-scale evacuations are necessary to safeguard those threatened. Mass evacuation of a PSN population is just as essential. Many PSN's are electrically or home healthcare clinician dependent. Communities impacted by large magnitude events often lose power and home healthcare clinicians are unavailable to work. PSN programs should also plan on “host” jurisdictions to take in PSN registrants from “risk” communities impacted by disaster. (CDRP, 2006) The same essential information necessary to effectively run a SpNS within a jurisdiction may also need to be shared efficiently in a risk-host evacuation situation.What ultimately produces all these capabilities is fast diverse sorting of registry information.

To date, the standard databases used by only a relatively few PSN program have not produce standardized or multi-variate reports. As an example, if you have a number of oxygen dependent registrants at a special needs shelter, if you’ve collected their flow rate needs in the program registry, you should be able to quickly calculate the oxygen needs of the entire shelter for a given amount of time. Currently such PSN resource planning insights are rare if not non-existent.

If the humane healthcare requirements of persons with special needs are to be addressed in an effective and efficient way, PSN programs must address the issues raised by the 2006 SpNS tabletop exercises. In a world judged by compassion for those less fortunate, to neglect or ignore persons with special needs during disaster means we as emergency managers are not measuring up.

The Special Population Information Registry (SPIN)

In 2008, the Center for Disaster Risk Policy was asked to initiate the research, and later the development of, an online database application to address the issues examined above. Using a “rapid prototyping” process unique to the Center, the SPIN Registry was designed, developed, beta-tested and eventually made available commercially to PSN programs in the U.S. What follows is a technical and programmatic description of the SPIN Registry and how it attempts to meet the challenges.

Technical Background

In very simple fashions, information technology has been used to manage special needs populations for quite some time. Many emergency managers have composed and maintained registries of persons with special needs using simple digital resources such as a basic text files, digital spread sheets or electronic word processing programs. While the approach of "something is better than nothing" indicates that these methods would solve the problem of being able to maintain special needs populations, they bring to light some key issues with regards to how these lists or registries can be managed by multiple personnel concurrently and their effectiveness in being integrated with other technologies such as GIS, call center applications and reporting suites. These methods are also problematic when dealing with the subject of accessibility in times of need. Traditionally, these types of documents are stored on a local resource inside a jurisdiction's network with limited or restricted access that often require special virtual private network (VPN) or other security enabled programs to gain access. Enabling users the ability to use information systems anytime, anywhere and via any platform dictates that an application be delivered via a common interface with high availability and via an agile communications path which does not require proprietary software, hardware or means of connectivity. To satisfy these needs, those maintaining populations with special needs can turn to the internet as their solution. Applications built with relational database backbones that are delivered via the internet provide users with the ability to access and manage their critical data from a multitude of locations over reliable and secure networks.

The database behind an online application can be likened to the structure that holds up a building. Database engines are primarily responsible for the back-end or behind the scenes processing of data stored in tables. Robust and scalable databases for online applications should be developed using a technology that supports relational database design. Relational databases can be used in very much the same fashion a text file or spreadsheet file are used to store lists. However, doing this greatly under utilizes the power of relational database abilities. Unlike simple text containers, databases offer a much broader spectrum of options that allow users to create, add, update and delete (CRUD) raw data. They also offer developers the ability to create specific relationships between data elements which eliminates the duplication of data. Additionally, modern relational database technologies allow developers to use Structured Query Language (SQL) to give users the ability to create customized reports and datasets that can be cross-walked and integrated with other applications. In order to make an online application truly robust and scalable, developers need to leverage the benefits of using enterprise level database technologies. Enterprise level database engines provide users with speed, efficiency and extended SQL capabilities that do not exist in more basic desktop caliber relational database technologies. Additionally, enterprise level database engines can be run on stand-alone hardware independent of external technologies such as web server platform or scripting language. Although these three technologies can coexist in a production environment, segmenting them and giving each its own dedicated hardware will greatly increase application speed, performance and availability.

For online applications, the web server acts as the visible part of applications. When users visit a website, what they are seeing is being delivered to their browser by a web server. The web server is a piece of software that runs on server hardware and answers requests made via the hyper-text transport protocol (HTTP). There are two types of HTTP requests that can be made, non-encrypted and encrypted. Encrypted browser sessions are denoted using the hyper-text transfer protocol secure (HTTPS) in conjunction with a Secure Socket Layer/Transport Layer Security (SSL/TLS) protocol to provide different levels of encryption. SSL/TLS connections are created when the web server offers a security certificate to the users' web browser. Once an HTTPS connection has been established, many browsers will display a lock and the communication between the browser and the web server is encrypted allowing sensitive data to be transferred bi-directionally over a secure connection. It is critical that any sensitive data that is to be transmitted over the internet be secured via an SSL/ TLS certificate.

The type of web server software that is run on the server hardware is dictated by several factors which include; the scripting language used to write the front-end of the application, the operating systems available and the level of security required to run the application. As with the choice of database technology, only enterprise level web servers should be used for hosting this application in order to assure reliability, scalability and guaranteed support of the product you choose. Jurisdictions without an internal IT department capable of supporting this technology can seek hosting from third party companies that offer dedicated hosting, shared hosting and cloud computing solutions.

As with any application, security is a major concern. The data assets are only as secure as the staff controlling the application. Some of the concerns faced are: cross-site scripting attacks (XSS), SQL injection, packet sniffing, man-in-the-middle attacks, OS level patching and exploits, database security and flaws in scripting language engines. When most people think of securing online applications, they most often only consider virtual security when it comes to the safe-keeping of web accessible data. One of the most overlooked areas of IT security is physical access to servers, data stores and end-user hardware. The physical protection of the servers is just as important as the virtual protection of the data. If the wrong people have physical access to the servers, they are limitless in their power to erase, steal, deface, manipulate and physically destroy data and IT assets. In the event of an authorized user maliciously damaging data integrity, the only way to trace the problem back to its source is to employ a transaction auditing system that records every step a user makes through the system. When an authenticated user is the primary vector of attack, forensic techniques can be used to undo the damage that has been done and data integrity can be restored. Additionally, access to reliable data backups can assist in the reconstruction of missing or incorrect data.

On a day to day basis, access to the online application is important and high availability to users is optimal, but the most critical time to have access to your data is in times of emergency. When an event occurs and special needs populations need to be evacuated and tracked are the times the application needs to be up and running. To ensure special needs data is available when needed, special consideration should be taken to ensure all data is backed up and regularly verified and that hot-spares are available. Although not always fiscally viable, backups and redundant fail-over assets should be hosted at physical locations not immediately impacted by the potential hazards the jurisdiction can experience. This may include having co-located assets in another state or country, depending on the needs of the users and jurisdictional regulations.

On August 21, 1996, the US Congress passed the Health Insurance Portability and Accountability Act (HIPAA), Public Law 104-191, which sets forth standards and policies regarding the use and management of patient health information. (U.S. Department of Health and Human Services, 2009) Organizations that must comply with HIPAA regulations include health plans, health care providers, labs, drug companies, payers (such as insurance companies), clearinghouses, dentists’ offices and any other entity that processes electronic patient data or is defined as a covered entity by the Department of Health and Human Services (HHS). Any business associate that has access to or transmits transactions including claims, insurance matters, remittances, claim status inquiries, eligibility, or certification must also be in compliance with HIPAA guidelines. Employers outside the health care sector are included if on site healthcare or health plan functions are provided by the company. (WatchGuard, 2002) Your choice to comply with HIPAA guidelines is dictated by the type of data that your application will contain. It is strongly advised that jurisdictions consult with legal counsel and the Covered Entity Charts provided by HHS to determine if they are subject to HIPAA guidelines. (Centers for Medicare and Medicaid Services, 2005) Additionally, HHS has developed an interactive decision tool designed to assist emergency preparedness and recovery planners in determining how to gain access to and use health information about persons with disabilities or others consistent with the Privacy Rule. (U.S. Department of Health and Human Services, 2009)

SPIN Development Process

Different jurisdictions across the United States use a variety of factors to determine Special Needs status. These factors can include medical conditions, equipment needs, psychological conditions, language barriers, and transportation deficiencies. The Registry Application was designed to capture all of these types of situations. Seventy three different registration forms were gathered from jurisdictions ranging from local counties to states. Each of these forms was analyzed for the specific information collected and these data points were aggregated into a master form that encompasses all seventy three separate forms. This master data collection form was then created by the interface design team to allow for logical flow through the various data types.

During design meetings, the team also examined how the registration data would be utilized by managers during all phases of emergency management. Designers immediately recognized that a traditional web based application would be unreliable during a catastrophic natural event such as a hurricane, tsunami, or earthquake. During these types of disasters, where infrastructure damage to power and data communications can be widespread and long term, end user access to remote web application servers could never be guaranteed.

Designers decided that the initial build of the system would be designed for use during the Preparedness, Recovery and Mitigation phases, but could not be a response tool.

Access to SPIN is accomplished through a standard Internet web browser, through an encrypted HTTPS connection. This universal access allows a wide range of emergency managers and community parters collaborate on the info contained in SPIN.

SPIN was built using object oriented web application design principles, utilizing Adobe ColdFusion as the application layer and the open source database MySQL as the database layer. Data access objects written in ColdFusion provide the connectivity between the presentation layer and business logic and the datastore. The system is designed to be scalable and easily moved from server to server.

Registrant data is entered into the system in one of four ways: self-registration, jurisdiction data entry, community partner data entry, or data import. While importing of existing data can be accomplished using a variety of data imports, manual entry of data is preferred. Existing Special Needs registration information in many jurisdictions is incomplete, inaccurate, and out of date. By importing that data intact into the registration application, those errors and inaccuracies are transferred to the new system. By manually reviewing and entering data by hand, the jurisdiction can attempt to start with accurate and recent information on the Special Needs population.

While the process of manual data entry can by tedious and time consuming, the registry application takes several steps to streamline the process. Each registrant data entry form is a single page view, and captures all information at one time. Additionally, jurisdictions can utilize their community partners such as home health agencies and assisted living facilities to enter information on their populations. The design team realized that these community organizations possess the most accurate information on the Special Needs population, and the registry system was designed from the start to facilitate partnerships with these organizations.

Access control to the data in SPIN is critical to the ongoing success of the system. The design team developed a list of user roles, and each role can be active for any number of organizational units in the system.

The user experience in SPIN revolves around the concept of organizations and user roles. Organizations are logical units in the application that contain users, registrants, transportation assets, and sheltering or evacuation locations. These objects can all be associated or contained within one organizational unit, or multiple organizational units.

Organizational units were designed to relate to one another in either a hierarchal way or horizontally. This allows for system administrators to set up organizational units in the way that best fits the real world organization needs.

Within SPIN organizational units, users can be assigned user roles, determined by the actions they need to be able to take in the system. Full control allows for the user to enter and edit Registrant information, assign the Registrant to organization assets such as transportation, and run reports based on Registrant data. Lower levels of access allow administrators to restrict edit/write permissions for certain users, and allow some users to only see aggregate report data.

Since SPIN contains sensitive medical information, the designer team implemented application security and audit protocols that ensure data control and privacy. Each database write access is logged by the system, including the date and time, originating internet protocol address, the authenticated user requesting the database write, and the data that was changed. Regulations in the United States, such as HIPAA, make it imperative that all data changes can be tracked, and SPIN can ‘roll back’ changes to any point in the data history; SPIN was designed to comply with these regulations.

Findings and Discussion

Once the data has been entered into SPIN, the emergency manager can manipulate and display the registry in almost limitless ways. SPIN's Reporting module allows both prewritten (called 'canned') and customized reports to be run at any time. All data points in the system can be used as part of a canned or custom multi-variate report. For example, an emergency manager can run a custom report for all registrants who require oxygen, live in a specific area, and need transportation to shelters. This flexibility gives emergency managers an excellent tool for determining shelter needs during the preparedness phase – prior to the storm or event. This capabiliy ties directly to a need established during the 2006 Special Needs Shelter tabletop exercise series.

SPIN also makes use of web based mapping tools to allow emergency managers to plot registrant locations on a web enabled map. This tool can be used output on any canned or custom report, showing all the matching records on the map interface along with complete sidebar data. Transportation planning was identified during the tabletops as an important challenge. By utilizing the data in SPIN mapping reports, the emergency manager can plan routes and movement for all the PSN's in her jurisdiction.

Data accuracy is key to any IT system being used as a special needs registry. SPIN allows emergency managers to partner with community agencies such as home health care organizations, the local health department, and the public to gather accurate information on registrants, and keep that information current. SPIN reminds managers when data one hundred and eighty days old, prompting them to follow up with registrants and their caregivers to ensure that accurate information is on file. This proactive reminder approach helps ensure that data is as accurate as possible for planning.

Beta Test Feedback and Discussion

In order to gain accurate usability information regarding SPIN, the system was deployed for five counties in Florida, Georgia and Alabama in 2009. During this testing phase, developers led many discussions with end users to gauge how well the system met their needs. SPIN developers set up a users wiki to elicit user feedback and documentation, as well as a deficit tracking system that was used to track software and infrastructure bugs. In a four month period, one hundred and fifty six bugs were logged and corrected.

One county, while receptive to the concept, was not willing to put time or effort into entering data or learning how to utilize the system. The remaining counties were impressed with several aspects of the system, summarized as follows:
Usability. SPIN was more accessible and usable that desktop based database systems or spreadsheets.
Accuracy. SPIN data was easier to keep current than paper based or spreadsheet based registry systems.
Reports. Unlike most other registry systems, the SPIN report architecture allows for limitless queries and reports, giving the emergency manager unprecedented flexibility in planning and preparedness.
Flexibility. SPIN allows the user to format reports in a variety of ways, export to PDF, export to Excel, and print maps. These capabilities allow users to find news ways to use SPIN to meet their needs.

Overall, the Beta tester feedback was instrumental in ensuring that the initial version of SPINwas as good as it can be.

Conclusion

Information technology, particularly customized software solutions, can greatly simplify the process of creating and managing a registry of Persons with Special Needs. This software registry can be cost effective yet provide functionality that many jurisdictions just don't have.

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PLR 分类指南在北京 LPG 存储与配送站事故偶发可能性上的应用

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【摘要】按照主要事故分类，如火灾，爆炸，有毒气体排放等，在北京，“事故偶发可能性”定义与方法的鉴定在“PLR 事故偶发可能性分类”中执行，沿用了灾害评估基本原理加上北京的事故发生与偶发可能性调查结果。综合三个评估因素，如，如事故的可能性（P），损失（L），影响区域（R），PLR 事故偶发可能性分类评估表被用来指示事故偶发可能性划分结果。这项新的研究成果在北京 LPGA 存储和配送站试用结果表明鉴别，评估与矫正是防止重大事故发生的关键。P，L，R 这三个标识事故发生可能性的子指标在不同程度上存在着差异。但是，只要精确的事故可能性鉴别与评估，控制及适当的矫正措施，最终，是会得到更多一致结果的。这种新方法使得试用单位意识到重大事故发生可能性的潜在风险，增强了其对重大事故风险的防范与纠偏意识。同时，新方法的可操作性与有效性也在试用中得到了验证。这项研究成果对生产、储存和使用易燃、易爆及有毒化学品的企业在灾害预防与安全评估上也有更加广大的应用前景。该研究成果对北京重大事故可能性鉴别，评估和改进提供了科学管理方法。

【关键词】北京；事故偶发可能性；评估方法；LPG 存储与配送站

APPLICATION OF PLR CLASSIFICATION GUIDE FOR ACCIDENTAL POTENTIAL IN BEIJING LPG STORAGE AND DISTRIBUTION STATION

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Keywords

Beijing; accident potential; assessment method; LPG storage and distribution station

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Abstract

According to major types of accidents, such as fire, explosion and toxic release, the definition and methods of identification for "Major Accident Potential" in Beijing were carried out in "PLR Classification for Accident Potential" , following the basic principle of hazard assessment combined with the survey of accidents occurred and accident potentials in Beijing. Combining three evaluating factors, i.e., probability (P), loss (L) and effect area ($R_{0.5}$) of the accidents, the "PLR accident potential classification assessment table" was proposed to indicate the consequence of accident potential classification. Through the trial application of the new approach in Beijing LPG storage and distribution station show that the identification, assessment and rectification of major accident potential were the key which prevent a major accident. The P, L, R sub-indicators of different type accident potentials existed difference of different degrees. But as long as an accurate identification and assessment of accident potential, control, appropriate corrective measures and, ultimately, there were more consistent results. The new ways made the trial enterprises became aware of the potential risks of major accident potentials, which reinforce awareness of the prevention and rectification to major accident potentials. Also the operability and effectiveness of the trial application of the new approach in Beijing LPG enterprises were verified. The approach had a more broad application prospects in accident potentials and safety assessment for enterprises that product, storage and use flammable, explosive, and toxic hazardous chemicals. The approach provides scientific management method in identification, assessment and improvement of mayor accident potential in Beijing.

Introduction

The prevention of accidents is the whole society common concern issue. A major accident potential hazard is a direct cause of leading to the major accident. Beijing is an international metropolitan and also an old industrial city, which has the old enterprises and more urban populations, high density business equipments. Due to lack of long-term investment, production and operating conditions and environment are poorer. The issue of a number of inflammable, explosive, toxic and hazardous business accident potential hazards is quite conspicuous. In order to promptly eliminate these major accident potential hazards and curb the occurrence of major accidents, Beijing every year carried out major accident potential hazards investigation and rectification work, listing in the list and proposing preventive measures and important monitoring.

Liquefied petroleum gas storage and distribution station is a major hazard, its safe and reliable operation relates to the social public security. LPG storage and distribution station is the important control points of the gas enterprise security production and a major monitor the target of gas industry supervision department. Potential safety hazard inspection carried out liquefied petroleum gas storage and distribution station can analyze, demonstrate and assess the possibility of generated losses and injuries, the affected areas, severity and measures from technology bringing about negative effects, which effectively prevent gas safety accidents. It can promote gas enterprises to realize intrinsically safe production, to improve their safety management level, to provide technical support for the decision-making and supervision of gas production safety supervision department. The paper used PLR accident potential hazard classification to identity, assess and rectify the potential hazard of liquefied petroleum gas storage and distribution station.

2. PLR accident potential hazard classification introduction

2.1 Definition

From the ILO "major industrial accident prevention and practical rules" [1] on the definition and classification of "major accidents", we can see that the international community generally believes that a major accident which specifically refers to "serious fires, explosions and toxic spills accidents."

A major accident potential hazard refers likely to result in significant personal injury or major economic loss accidents. Combined population of Beijing and business equipment density, major and serious accidents occurred less. The PLR accident potential hazard classification delimits that a major accident potential hazard for Beijing is "the accident potential hazard possibly resulting in death more than one or possibly causing direct economic loss of ￥1 million".

The accident potential hazard evaluation qualitatively and quantitatively analyzes size of potential ability caused the accident in the system and obtains the assessment on the likelihood and the loss extent of the accident [2]. The specific content of the accident potential hazard evaluation includes potential hazard identification, potential hazard category division, potential hazard classification division and potential hazard prevention, rectification measures etc.

The application scope of PLR accident potential hazard classification:

(1)The major hazard that involves the production, storage and use of dangerous chemicals in the chemical storage area and the production sites [3] (Consistent with the application range of the GB18218-2000 "a major hazard identification" [4], namely, the companies or organizations that product, use, store and manage dangerous substances).

(2) The chemical enterprises which lead to happen to "death more than one or possibly causing direct economic loss of ￥1 million" fire, explosion, leaking toxic major accidents.

2.2 Identification method

Identification methods of Beijing fire, explosion, toxic leak major accident potential hazard as follows:

(1) Combined with the international identification methods of leading to the fire, explosion and toxic leak major hazard, citing the national standards of "major hazard identification" (GB182118-2000) in dangerous substance classification and critical value of the tank area, reservoir and production workplace as identification standards.

(2) In comparing to "major accident potential hazard" definition, namely, the accident potential hazard which likely lead to death more than one or possibly causing direct economic loss of ￥1 million is considered as whether is "a major accident potential hazard".

2.3 Classification Method

If accident potential hazard is identified as the major hazard or a major accident potential hazard, it is further determined the probability of accident potential hazard and the extent of losses which accident potential hazard caused. It quantitatively calculates the influence scope of the accident consequences (the lethal radius $R_{0.5}$), and finally grades to a major accident potential hazard by Beijing major accident potential hazard grading assessment table [5].

Table1. Beijing major accident potential hazard grading assessment table

the probability of accident potential hazard(P)	the extent losses of accident potential hazard *(L)(The number of deaths and economic losses)	the influence scope of the accident consequences(the lethal radius $R_{0.5}$ unit：meter)			
		0～10	10～50	50～100	≥100
Not likely occur	≥1people or ≥￥1 million	Ⅰ			
	≥ 3people or ≥￥5million				
	≥ 10 people or ≥￥10 million				
Occasional occur	≥1people or ≥￥1 million		Ⅱ		
	≥ 3people or ≥￥5million				
	≥ 10 people or ≥￥10 million				
Some time occur	≥1people or ≥￥1 million			Ⅲ	
	≥ 3people or ≥￥5million				
	≥ 10 people or ≥￥10 million				
Easy occur	≥1people or ≥￥1 million				Ⅳ
	≥ 3people or ≥￥5million				
	≥ 10 people or ≥￥10 million				

Note: According to the previous description and the definition of the "major accident potential hazard," the starting point of the extent losses of accident potential hazard are defined" death more than one or possibly causing direct economic loss of ￥1 million" as the standard.

The results show from Table 1 PLR accident potential hazard classification, the major accident potential hazard classification is divided into four grades, including Ⅰgrade potential hazard hidden (slightly dangerous, pay attention), Ⅱgrade potential hazard (possible dangerous, pay close attention), Ⅲgrade potential hazard (more dangerous , timely rectification), Ⅳgrade potential hazard (highly dangerous, immediate rectification).

The results show from Table 1 PLR accident potential hazard classification, the major accident potential hazard classification is divided into four grades, including Ⅰgrade potential hazard hidden (slightly dangerous, pay attention), Ⅱgrade potential hazard (possible dangerous, pay close attention), Ⅲgrade potential hazard (more dangerous , timely rectification), Ⅳgrade potential hazard (highly dangerous, immediate rectification). It means that Ⅰgrade is allowed to accept the scope, Ⅱgrade is included in the enterprises to prevent accident potential hazard scope or is included in the rectification scope if enterprise funds allow, if the enterprises exists Ⅲor Ⅳgrade accident potential hazard and requires the specialized agencies to conduct a comprehensive assessment for the mayor accident potential hazards and after the experts assess, forming a formal assessment report to implement corrective measures. Where there are mayor accident potential hazards in the enterprises need to implement regular tracing, monitoring and inspection for the rectification of potential hazards, making, training and maintenance of major accident emergency rescue plans by specialized agencies.

3. Identify and analysis on the dangerous and harmful factors in LPG storage and distribution station

According to GB/T13861 "classification and code of hazardous factors in the production process", there are many dangerous and hazardous factors when the storage and distribution station is running. The direct causes of the accident are physical, chemical, biological, psychological, behavioral, and other six categories dangerous and harmful factors. According to GB 6441 "enterprise workers casualties", the accident categories of storage and distribution station have scorching hot, electric shock, fire, container explosion, poisoning choke, mechanical injury, high falling and so on.

In accordance with the safety system engineering analysis, the basic reason of dangerous and hazardous factors exist the energy in the system, coupling with hazardous substances out of control. Therefore, the dangerous and hazardous factors identify whether the system exist the energy and harmful substances and how to control these energy and harmful substances. Dangerous and hazardous factors from the form can be divided into three categories such as the inherent dangerous and hazardous factors (that is, dangerous and hazardous factors of material and production process), related, storage and transportation dangerous and hazardous factors.

3.1 Identify on the inherent dangerous and harmful factors in LPG storage and distribution station

The substance dangerous and hazardous factors identify from physical and chemical properties, stability, chemical reactivity, combustion explosion characteristics, toxicity and health hazards etc. According to the characteristics of liquefied petroleum gas, there are burning explosion hazard, chemical frostbite, poisoning and asphyxia, chemical corrosion and other aspects dangerous factors.

Dangerous and hazardous factors are often not a single and often associated with a number of dangers, so it is necessary to identify the coverage and matter energy damage properties of the dangerous and hazardous factors. Once LPG storage and distribution station fire accidents, it is rapid fire, great disaster losses and influence. Volatile characteristics of liquefied petroleum gas and the accident hidden should be conducted related harmful factor identification.

3.2 Identify on the related dangerous and hazardous factors in LPG storage and distribution station

Dangerous and hazardous factors are often not a single and often associated with a number of dangers, so it is necessary to identify the coverage and matter energy damage properties of the dangerous and hazardous factors. Once LPG storage and distribution station fire accidents, it is rapid fire, great disaster losses and influence. Volatile characteristics of liquefied petroleum gas and the accident hidden should be conducted related harmful factor identification [6].

3.3 Identify on the storage and transportation dangerous and hazardous factors in LPG storage and distribution station

Storage and transportation of liquefied petroleum gas is an important and indispensable part in production and operation. The dangerous and harmful factors are identified from hazardous characteristics and storage and transportation process, such as the dangerous and harmful factor identification of liquefied petroleum gas tankers and liquefied petroleum gas cylinders storage and transportation process [7-8].

3.4 Major hazard identification of LPG storage and distribution station

Major hazard refers to the unit which chronically and temporarily to product, process, transport, use and store hazardous substances, and the quantities of hazardous substances equal to or exceed the threshold quantity [3]. Major hazards are divided into two main categories such as production sites and storage sites major hazards. According to GBl8218-2000 "major hazard identification", it identifies the major hazard of LPG storage and distribution station.

(1) The bottle filling area, railway trestle bridge area, loading and unloading areas of tanker and automobile in the production sites of LPG storage and distribution station do not constitute major hazards;

(2) According to GBl8218-2000 "major hazard identification" 33 items of Table 2, the threshold quantity of LPG storage area is 10t. According to the relevant regulations of National Quality and Technical Supervision, the storage capacity of LPG in LPG storage and distribution stations is greater than $50m^3$(about 22t). Thus, the storage areas of China's LPG storage and distribution station basically constitute major hazards.

(3) According to GBl8218-2000 "major hazard identification" 33 items of Table 2, the threshold quantity of LPG storage area is 10t. According to China's popular VSP-15 type (capacity 15kg) specification cylinder calculations, when the cylinder storage capacity of the cylinder library is greater than 690 bottles, it is a major hazard.

4. Application of PLR accident potential hazard classification in LPG storage and distribution station

4.1 Selection basis of experimental units

(1) The enterprises exist the tank area, reservoir and production workplace which product, process, use and store major hazard.

(2) In recent years, LPG enterprises had been "death more than one or possibly causing direct economic loss of ￥1 million" fire, explosion, toxic leakage major accidents.

Based on the above principle, in 2009-2010 carrying out research projects period, the task group has visited dozens of relevant units Beijing Gas Group, conducting field identification and related data collection to the major accident potential hazard of the pilot units. After several on-site survey and communication with the factory management on safety and merging with the type of units, it obtained the summary of PLR accident potential hazard classification application results in pilot units (Table 2).

4.2 Application results of experimental units

(1) Most of the computing unit grades of the probability of accident potential hazard (P) are rated as "occasional" or "not likely occur".

(2) According to the specific assets of the various computing unit estimation results diversity, the extent losses of accident potential hazard (L), namely, three kinds of accidents grades all caused economic loss and the deaths.

①≥1people or ≥￥1 million; ②≥ 3people or ≥￥5million; ③≥ 10 people or ≥￥10 million

(3) According to different calculation unit and the different calculation of accident types, half of the lethal radius ($R_{0.5}$) has different values which ranging from 26.8 ~ 96.7m. PLR accident potential hazard classification application results show that the calculation of the radius and staff half of the death area of actual incidents is basically consistent.

Table2. Summary of PLR accident potential hazard classification application results in experimental units

The experimental units	Device computing units	Types of potential accidents	PLR accident potential hazard classification			Classification result of PLR accident potential hazard
			the probability of accident potential hazard(P)	the extent losses of accident potential hazard *(L)(The number of deaths and economic losses)	the lethal radius $R_{0.5}$ (unit：meter)	
Application unit A	Loading and unloading trestle unit	Flammable gas explosion	Occasional occur	①≥2people or ≥￥5 million ②≥2people or ≥￥1 million	①58.8 ②40.7	II
	Storage Unit	①Flammable gas explosion ②fire	not likely occur	≥￥10 million	96.7	II
	Cylinder library unit	①Flammable gas explosion ②fire	not likely occur	≥￥1 million	36.5	I
Application unit B	Bottling area unit	①Flammable gas explosion ②fire	occasional occur	≥10people or ≥￥5 million	60.6	II
	Storage Unit	①Flammable gas explosion ②fire	not likely occur	≥￥10 million	89.3	II
	Cylinder library unit	①Flammable gas explosion ②fire	not likely occur	≥￥1 million	43.2	I
Application unit C	Loading and unloading trestle unit	Flammable gas explosion	not likely occur	①≥2people or ≥￥5 million ①≥2people or ≥￥1 million	①50.2 ②34.7	I
	Storage Unit	①Flammable gas explosion ②fire	not likely occur	￥10 million	87.9	II
	Cylinder library unit	①Flammable gas explosion ②fire	not likely occur	≥￥1 million	26.8	I
Application unit D	Bottling area unit	①Flammable gas explosion ②fire	not likely occur	≥2people or ≥￥1 million	36.8	II
	Storage Unit	①Flammable gas explosion ②fire	not likely occur	≥￥10 million	78.9	II
	Cylinder library unit	①Flammable gas explosion ②fire	not likely occur	≥￥1 million	42.6	II

Controlling Beijing major accident potential hazard grading assessment table(Table 1), it could be drawn the accident potential hazard classification results of combining P, L, R three indexes, most of which the classification result of computing units was Ⅰ grade potential hazard hidden (slightly dangerous, pay attention) or Ⅱ grade potential hazard (possible dangerous, pay close attention). This shows that different calculation units P, L, R sub-index represents the different degrees dangerous of the calculation unit in the PLR classification evaluation. The differences of the sub-index value in different units can be large (such as $R_{0.5}$). But as long as the daily management is rigorous, and control measures properly, the accident potential hazard comprehensive evaluation the results of most units are at acceptable grades (Ⅰ ~ Ⅱ grade).

5. Conclusion

(1) In the pilot application of Beijing LPG storage and distribution station major accident potential hazard units, PLR accident potential hazard classification analyzed flammable gas explosion, tank fire, toxic leaks and the accident consequences of many other modes. The units selected were representative and the applied results of PLR accident potential hazard classification were credible. That was verified the scientific, practicability and promotion of PLR accident potential hazard classification.

(2) The pilot application results of PLR accident potential hazard classification showed that the identification, assessment and rectification of major accident potential were the key which prevent a major accident. The P, L, R sub-indicators of different type accident potentials existed difference of different degrees. But as long as an accurate identification and assessment of accident potential, control, appropriate corrective measures and, ultimately, there were more consistent results. So the status of the accident potential hazard of pilot units was controlled within the acceptable grade.

(3) Research project made to the calculation of the accident consequence influence scope ($R_{0.5}$) procedures. With the use of PLR classification evaluation form, it was more quick and easy to the application of PLR accident potential hazard classification.

In short, the application of PLR accident potential hazard classification in Beijing LPG storage and distribution station in the application made pilot enterprises know the major accident potential hazard dangerous and strengthened the prevention and rectification awareness to the major accident potential hazard. That is further verified the operability and effectiveness of PLR accident potential hazard classification in Beijing LPG storage and distribution station evaluation. Research project developed the accident risk calculation software package, creating favourable conditions for PLR accident potential hazard classification to promote and making it in the accident potential hazard and safety evaluation of production, storage, use of flammable, explosive, toxic and hazardous chemicals units more broad application prospects.

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IVS 即安全

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【摘要】IVS®是上海新联科技有限公司的产品，它是一种新型基于分布式 IP 网络架构的，实时游客流管理智能视频系统。使用最新的计算机视觉识别技术，实时游客流量统计分析，带实时预警的安全保护措施，图像识别，节能控制，个人安全监管区域，如访问一个好的应用。系统的灵活性，先进性，成本及其它方面已经完整展示了其优越性。

【关键词】IVS® 智能；视频识别；游客流统计；模式识别；神经算法

WHERE IVS WHERE SAFETY

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Keywords

IVS® Intelligent, Video Recognition, Passenger Flow Statistics, Pattern recognition, Neural Algorithm

Abstract:

IVS® is provided by Shanghai NewLan Co, it can be described as a newly designed intelligent video system which based on Distributed IP-based network architecture for Real-Time Passenger Flow Management. By using the latest computer vision recognition technology, passenger traffic in real-time statistical analysis of safety precautions dealing with real-time alerts, image recognition, energy-saving control, and personal safety oversight areas such as access to a good application. Flexibility of the system, advanced, cost and other aspects have been fully reflected its advantages.

Introduction

This paper will introduce the new Intelligent Video Surveillance System (Named as IVS ®)in detail to let you know how the system works and the structure of it with examples. The using prospect of this system will also be discussed. The evolution of video surveillance technology has gone through four phases. First phase: analogy video surveillance system. Second phase: the digital video surveillance. Then the network-based monitoring system pushed it into third phase. During this period of time, there are still a lot of defects on people-oriented video surveillance technology:

a) Traditional video surveillance on artificial, consume a large amount of manpower, are limited in human resources of various defects, time-consuming and labour-intensive and inefficient. Studies have shown that if one person observes with two monitors, he/she will miss 45% of the useful information in the first 10 minutes. 22 minutes afterwards 95% of the useful information will be missed. IF this person is observing more monitors he/she will be even more focused. It is not just hard to concentrate on monitoring. Also the observing person will get distracted all the time by some other objects which made it even less effective.

b) A large number of cameras require huge amount of manpower to observer. The main function of Video Surveillance is to get the "Later evidence". It lacks on real-time alarm.

So the forth phase of Video Surveillance is introduced for the video monitoring technology which called Intelligent Video surveillance analysis techniques. Intelligent Video Surveillance analysis technique based on decades of research-based artificial intelligence, computer vision software analysis and neural algorithm, combined with a wealth of human and object behaviour recognition library, automatic identification events, real-time notification, 24/7 non-stop working, minimize false positives, false alarm rate. Nowadays Intelligent Video Surveillance has been developed as a universal application of mature products in many developed countries. IVS® has played an active role in passenger flow management at the Shanghai World Expo to making an average of 400,000 passengers (extreme peak of 800,000 passengers) orderly flow of the exposition area in about 6 square kilo meters. It will also reduce the harms caused by passenger traffic extent to a minimum, change the distribution of passenger traffic for the orderly management of disorder. IVS® is expected to be promoted in the next several years to everywhere in the world and will be developed as a mature products for universal applications.

Thesis

<u>1. The IVS® features and control system.</u>

(A) The basic hardware architecture of the system

IVS® is based on the rapid development of the internal and external network architecture on top of distributed systems. As Figure 2-1-1 shows, it can be applied to a modern intelligent building.

A complete video monitoring system mainly includes four modules:
a) Video capture devices.

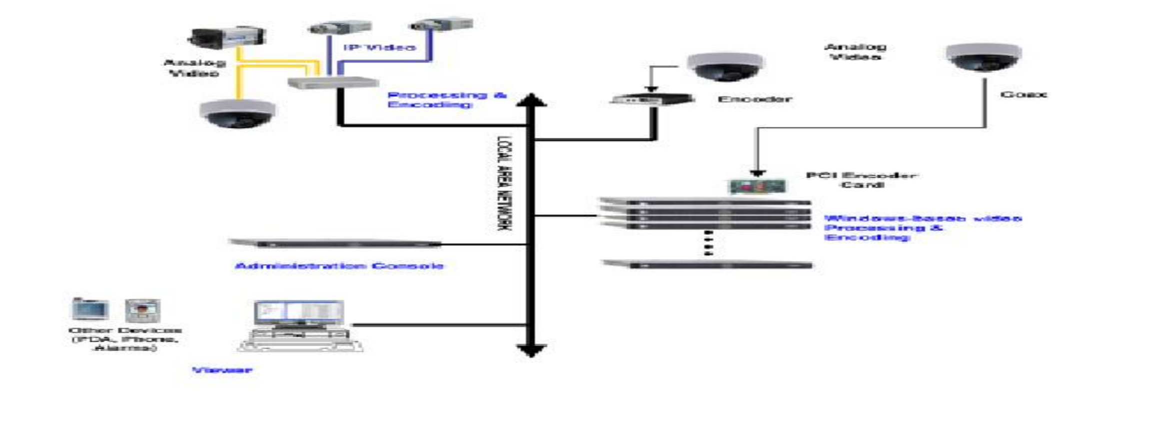
b) Video analysis server.

c) Monitoring terminal.

d) A network connection incorporates all the above modules.

(B) Video capture device

Acquisition equipment generally has traditional analogy cameras and IP cameras. They located in every corner to monitor inside and outside the building. The image output rate will have different requirements on different applications of intelligent analysis. E.g. High and low resolution camera, with or without PTZ (Pan/Tilt/Zoom) functions. The setting of camera’s height, angle etc while installation is completing will also perform a significant analysis result. As the back-end of the video analysis and management software are running on the IP network environment, so even if analogy cameras can still convert to IP video through encoders. Because of IP network's excellent interoperability and compatibility, they are gradually replacing the analogy system-wide trends. However, in actual building construction environment, particularly in the building have already been set up video cameras, its internal existing network structure has to be considered. At the same time the camera is subject to the power required for construction projects in the power system constraints. But now this can be solved and save the cost because IP cameras now have the use of Power over Ethernet (PoE). In general case, the camera's sensitivity will depends on high/low brightness. IP cameras have less capture quality than analogy cameras. Therefore, indoor and outdoor lighting conditions, and lighting systems will also directly affect the selection of video capture device. In a longer period of time in the future, a mixed analogy and IP video capture environment will continue to exist.



2-1-1 System Structure

(C) Passenger flow analysis server

This module's main function is to use advanced computer vision technology and neural algorithm for the collection which come from a variety of different application level video analysis.

By logically, the whole system set up management, video storage and playback, database, event query and user permission management is also part of this module; in the physical structure, our design is based on actual customer needs, combined with a distributed network, can be divided into sub-modules or as one part. The first step is to choose server hardware. Different intelligent analysis, the computer's processing performance could make a big difference in between. Since the emergence of multi-core CPU and fast upgrading of hardware computing power constraints are gradually improving. PC class server architecture will be the development trend. 1U or 2U rack server is very suitable for buildings with room set up. The server's operating system should mainly be Microsoft's Windows Server or a variety of Linux open-source products which both now have a better functional performance and stability. The choice should depend on a suitable server software platform of application and affordable prices. For large systems, as the core of the analysis software can be distributed across multiple hardware platforms. Each server should process a multi-channel video input. Processing results can be integrated into the independent controlled server. A controlled server generally can handle the entire system setup and management with its own web server and the database system. Also, because of video file's large capacity, we must consider multi-level storage structure. This can be done by choosing from the fastest local hard disk to the network, NAS or the final end of the tape storage. According to the specific needs of the user's design data backup methods, algorithms and data compression program, to get a stable system reliability, for the key hardware and software, such as the control server may be based on their information processing capacity / speed requirements, could be considered to use two stand-alone system, plus the load balancer (load balancer); the database self-provided the main from the service features and hot backup and array (cluster) with a variety of different programs cost.

(D) Passenger Monitoring Terminal

As the directly end-user interface of entire system, the developing speed of monitor terminal is rapid. With the traditional sound, lighting and other alarm systems continue to exist; e-mail, text messaging and a variety of wireless devices based options will bring great convenience to users and managers. Our system has its own Windows-based Web monitoring program. For a large number of third-party end-products, the system also provides serial interface, TCP / IP interface or upper to XML-based Web services. Nowadays more and more wireless or PDA-like devices have the IP network and Web browsing support, so to put them all to the monitor terminal is an inevitable trend.

(E)Network Connection

Network linked above modules all together. In general, the backbone network connect to the server will be Fast or Gigabit Ethernet structure; some IP cameras and monitoring devices can be connected with the wireless Ethernet access if necessary. If mobile phone or a remote camera is required, then the telecommunications network and Internet will also become part of the system. Because of the video’s self-capacity and time-sensitive, network bandwidth and latency will be an important consideration during the system designing period. We can separate subnet, connect via router connection; or a virtual network (VLAN), with the switch to connect the regional video capture devices and servers. Since we use an open IP network architecture, safety and security of the data will be a new challenge. While we are designing data source and the server, all the connections from the server internally to the server-to-end transmission, have to be the best combination of effectiveness and safety.

2. The characteristics of software algorithms

The core of this system is IVS® analysis software. This system incorporates several decades Machine Learning, Computer Vision technology and Neural algorithm, by using the most advanced and mature technology to analyse images from a variety of camera information to make the result to be accurately, efficiently and intelligently and automatically filter, process a variety of events under complex environment. Compare to traditional Intelligent Video Monitoring system, the difference is that our product is focused on dynamic environment on solving all kinds of meaningful changes in behaviours. With the optimized dynamic detection engine and a unique static detection engine, it is able to exact a dynamic environment, analyse and detect meaningful dynamic and static events, which have the ability to analyze these significant events. During the same time, with this product’s high intelligence and adaptive, once settled up then the system can adjust the parameters, without human intervention but with a very high practical value.

(A) Static changes in dynamic environment identification

In a natural environment, brightness and other background information change with time and weather change. In this dynamic environment, to conduct such as "a vehicle to stop," or "a thing to move" This kind of static changes in the identification, the core issue is the background of the dynamic modelling. Compared with other traditional techniques, our dynamic model consists three levels of modelling, they are the full screen-level (frame level), the regional picture-level (region level), and pixel level (pixel level). With a perfect dynamic background model, it is able to absorb or ignore as a whole (indoor light, sunlight, etc.) and local (cars, pedestrian flow, leaves, shadow, etc.) unrelated to dynamic events. Normal intelligent software is only pixel-based analysis, our technology is not only suitable for indoor stable lighting environment, but also freely to cope with the ever-changing outdoor environment with higher accuracy rate, very small false alarm rate which can achieve a real and practical level. In addition, because of the automatic adaptive modelling, it has more convenient to use. Users do not need to manually change parameters while environment changes after installation, and thus be truly smart fully automated operation.

(B) Identification of specific dynamic in a dynamic environment

The traditional dynamic event recognition technology can be divided into two categories:

a) MOTION DETECTION. This is the first generation of detection technology basically no intelligence at all, because it is just comparing two images before and after the pixel is different from a slight sign, any changes could produce false alarm and can not distinguish meaningful events.

b) Based on BLOB (prospects regional) analysis. The basic steps are: firstly to get background comparison, get BLOB, and then from each BLOB to extract features and compare the behaviour of the existing library to analyse and identify a variety of objects. This solution mainly depends on the BLOG extractive precision, because of the BLOB extraction in computer vision has image segmentation (SEGMENTATION) issues, subject to various environmental factors, and there is still no perfect solution for it.

Considering of these two detection systems are insufficient, the dynamic testing system we designed comes with a new idea, to avoid the dead angle of computer vision science and bottlenecks, reporting directly to the current frame (FRAME) prospects for feature objects (such as the human body) for modelling and extraction.

The regular feature extraction is based on pre-defined number of manual features (preset feature), such as the shape of a dog (nose + eyes + ears + legs + tail) etc, but the disadvantage of this is not able to self-adaptive, if angle or feature slightly changes, it stops extracting features. Our approach is to optimize the machine learning technology to automatically select and extract meaningful features ensure a higher precision and adaptive capacity.

Compare with the old algorithmic method, our algorithms considered the occurrence of noise, through the optimization algorithm to minimize the occurrence of the error, ignore the noise generated by the core algorithm.

3. The Using of IVS® Control Technology

(A) Passenger Flow management at World Expo 2010 Shanghai

2010 Shanghai World Expo is the world's attention event. It is to demonstrate the latest achievements of human civilization and development trends of the most authoritative and largest fair. 2010 Shanghai World Expo will last for 6 months, will be about 200+ participating countries and international organizations, domestic and overseas tourists expected to be approximately 70 million visitors come to visit, with an average of 400,000 per day. 600,000 on the peak time, 800,000 on extreme peak time. Expo will have a huge passenger flow area of roads, stadiums, squares, etc., causing tremendous pressure. Without effective guidance, it is easy to form the uneven distribution of passenger traffic and even partial crowded conditions, leading visitors to wait for longer waiting period which wasted time and cause more safety and security issues. "Better City, Better Life" is the direct embodiment of the Expo theme, efficient passenger flow-guided to avoid repeating the Aichi World Expo which results of overcrowding and long queues caused by tourists and decreased tourist satisfaction. And also attract more tourists to visit the Expo, to help the World Expo to archive 6 billions sales target based 50 million tickets sell plan.

How to estimate through the real-time data collection, scientifically analysis, effectively guidance strategies, timely and effectively release guidance information to maximize the control over the visitors in the field within a reasonable and orderly manner to passengers. To get the balance point of maximum visitors' satisfaction, attracting and promoting ticket sale, this is the most urgent issue that requires to be solved for the World Expo. Therefore, we have developed IVS® Video Analysis system for real-time passenger flow analysis. It uses the intelligent video recognition technology to estimate crowding and other issues to get the best solution.

(a) Passenger statistics

The passenger statistics of aisle is an important topic in emergency management. There are a variety of solutions appeared in history, such as mechanical, One-dimensional light perception as well as RFID. Mechanical devices will affect the flow rate, leading to channel block. One-dimensional light perception should be used only adapted to a narrow channel. RFID requires everyone to carry ID transmitters and always over budget. Low accuracy rate will caused with high interference in crowded situation. (80%)

3-1-1 The passenger statistics of aisle

3-1-2 Square passenger traffic crowding

®NEWLANWISE passenger counting technology of IVS® is using the latest artificial intelligence, machine learning and computer vision, Neural Algorithm and multi-target tracking technology. It could do an exact count either outdoor, wide channel or crowded complex cases (as shown in Figure 3-1-1). It achieved more than 90% accuracy rate in the most complex operating conditions in last six months testing period without and need of manual adjustment.

It can be widely used for exhibitions, large-scale art, sports venues, airports, supermarkets and other places for the need of passenger traffic statistics and analysis.

(b) Real-time crowding monitoring

Real-time crowding monitoring has broad application prospects, such as the prevention of congestion collapse and to prevent Staff stampede. Due to the limited scope of monitoring conventional sensors can not meet the square distribution of real-time crowding monitoring. IVS® is using computer vision adaptive background modelling and single viewpoint projection correction techniques. Through a single camera to achieve a large area real-time crowded monitoring. Also the software has the flexibility to set up single or multiple regions, the number of simultaneous analysis of various regions, the distribution of personnel to be real-time information. Figure 3-1-2 Shows Nanjing Road Shopping area passenger traffic analysis results at night the. Staff can get real-time analysis of the passenger number and average speed and other information.

3-1-3 Current Crowding Chart

Figure 3-1-3 is the daily crowding statistical table. For a control area, to compare the current staff density with the average density, IVS® responds fast to suspected situation. Ease to provide for the timely and effective scientific solution.

(B) IVS® Real-time alarm.

Using IVS® technology as software modules then embedded into digital video surveillance system to achieve in the demarcation region suspect cross-border alert to replace the conventional infrared boundary PTZ tracking intruder alarm. (Figure 3-2-1)

Set illegal movement of good monitoring and long-time lift good detection and suspect object alarm (Figure 3-2-2).

People facial recognition, vehicle identification and illegal detention.

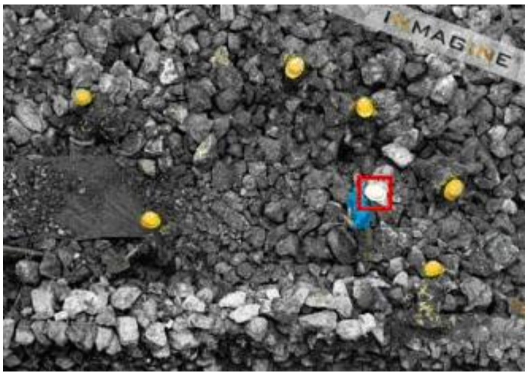
Various types of alarm sensors can be combined to conduct a comprehensive analysis of the collection of information to determine, support monitoring personnel manually set alarms

	
3-2-1 Illegal Enter	3-2-2 Long time lifted suspected object

(C) IVS® on energy-saving control

In large shopping malls and buildings daily operations, air-conditioning and lighting account for a large proportion of the consumption. In order to save cost and use energy effectively, to know where the personnel distribution during real-time is important. General Conventional sensors can only be placed in the entrance room to grasp the total number of passers rather than to detect specific distribution.

Figure 3-3-1 showed the result of a large shopping mall is using IVS® passenger traffic density monitoring and analysis. Based on real-time information, control personnel will be deployed. With the BAS integration it could more effectively control the region, lighting, fresh air volume, temperature and humidity in order to achieve the energy saving effect.

	
3-3-1 Shopping Mall real-time density monitoring	3-4-1 Wearing safety helmet supervision

(D) IVS® on Construction site safety supervision

Safety issues in construction site is very important to developers, we must take the necessary security measures. While at the construction site wearing a helmet is a must, because of previous lack of effective detection methods, but which are frequently violated.

The use of IVS® monitoring system (as shown in Figure 3-4-1) in time to find that not wearing a full helmet personnel. As the video surveillance, spot images can be sent to management. And the management do not need to go to the site, they could just through a web camera to confirm the rectification of the situation.

3-5-1(a)Flame Appear	3-5-1(b)Result of Flame detection

(E) IVS® on large buildings in fire monitoring and control

In the United States there is an average of 120,005 non-residential fires cases each year, the direct loss of more than 1.1 billion U.S. dollars. There is no fire warning device in 72% of the fire scene. The reason is the traditional fire monitoring devices (e.g. Particle-based smoke-sensing devices) can not be able to supervise large space structures effectively. Therefore, two-dimensional or three-dimensional coverage video surveillance with the based on the speed of light sensors high-speed video has a great advantage. IT makes video surveillance into a major space in the building and linked with fire alarm to achieve the best solution.

In recent years, highly adaptive computer vision recognition technology greatly enhanced the monitoring accuracy of the fire in the natural environment and achieved the low false alarm rate. Figure 3-5-1 shows the result of using adaptive background modelling algorithms and the flame recognition technology. In this large space of the working area, IVS® can detect in the early formation of the flame.

3-5-2(a)Smog Appears	3-5-2(b)Result of Smog detection

IVS® can not only monitor the flames, but also smoke. Figure 3-5-2 show in high-roof stadium smoke identification. Intelligent recognition algorithm can effectively identify the formation of smog.

Conclusion

Based on artificial intelligence and computer vision, intelligent video subjects on the basis of identification and control technology will become widespread with continuously improved the performance software, network technology and hardware equipments.

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Gang Cheng, Male, was born in 1974. Started work since 1996, Centralized Control System degree, now works in Shanghai NewLan Co., Ltd as Technical Manager. He has been involved in the company power plant simulation control system design and debugging; automatic identification logistics control system design and development; computer network system design and planning; digital video surveillance system design and implementation; intelligent video recognition technology application system design and implementation; participating companies bear National Science Department and Technology "Expo area passenger traffic guidance systems development and engineering applications based on radio frequency identification technology " (2007BAK27B02). Also be part of in the research and development of company self-invented "IVS" Intelligent Video Management System passenger traffic applications.

通过实时调整运行方案来应对高速行驶火车出现的故障

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【**摘要**】不可预见的紧急事件或基础设施缺陷可能导致高速铁路运营时间的混乱。如何防止干扰和影响，采取何种行动来快速解决紧急故障是在这一文件中讨论的。我们提出优化的数学模型，来改良列车线路和重新安排计划，以尽量减少影响的传播。此外，我们建议用一种可以模拟真实情节的软件，来模拟高速铁路运行过程中的实时调整在应付紧急情况下是可行性和实用的。

【**关键词**】高速铁路；转换失灵；重定计划；最佳模型；约束设计

A REAL TIME TRAIN RESHCEDULING IN CASE OF SWITCH FAILURE IN HIGH SPEED RAILWAY

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Keywords

High speed railway; Switch failure; Train rescheduling; Optimization model; Constraint programming

Abstract

Unforeseen emergency events or infrastructural defects may cause timetable disturbances to high speed railway operations. How to prevent disturbances from impact propagating and what actions to take in case of switch failure are discussed in this paper. We present a mathematical optimization model for train rerouting and rescheduling in order to minimize the propagation of the disturbance. Furthermore, we propose a solution based on standard optimization software for real scenarios, its feasibility and practicability are proved by a simulated high speed railway operation's real time rescheduling to respond emergency situation.

Introduction

With the rapid development of high speed railway (HSR) in many countries, its safety and punctuality have become more and more significant concerns in showing its competence over other modes of transportations,

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such as airway. To make high speed trains safer and more punctual, there are a lot of factors to be emphasized, including the quality of building railroad infrastructure, the use of advanced communication/ control signal system and the effectiveness in railway operation. Given existing railway "hardware", HSR operation companies must employ effective manners to organize train trips so that trains can travel as close to the planned timetable as possible.

However, with the increase of train speed and running frequency, a small perturbation may cause large number of trains being delayed. Disturbance emergencies include equipment failures, unexpected track possessions, nature disasters, etc. In real-world operation, equipment failures constitute most of the disturbance emergencies, in which switch failure is one of the severest situations. For example, 5 cases of severe switch failure occurred on Tai Wan high speed railway in only 5 months (Mar. 2009 – Aug. 2009) (Tai Wan CDNS 2009). Even the case in August itself caused thousands of passengers being affected, 5 trains being cancelled and 20 trains being delayed. Recently (Mar. 2010), Tai Wan high speed railway was serious affected by the earthquake, 5 trains were compelled to stop on the track. Furthermore, 1 train was derailed (CNR 2010). Thus, how to reroute and reschedule the affected trains in case of switch failures will be discussed in this paper.

A railway switch is a mechanical installation enabling railway trains to be guided from one track to another at a railway junction. When a switch fails to be positioned onto the expected direction, the coming trains will not be able to run along their planed routes. The complexity of re-planning the affected trains varies with different situations of switch malfunction, as illustrated in Fig.7.

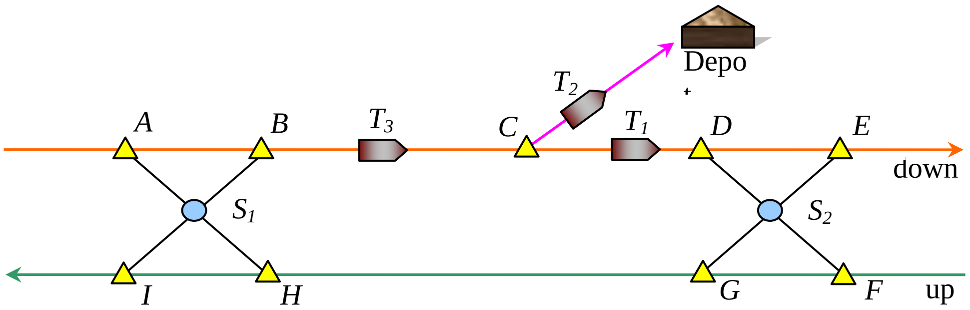


Fig.7. Different impacts of various switch malfunctions.

In Fig.7, S_1 and S_2 stand for two stations on a double-track rail, *A*, *B*, *H*, *I* are the switches directing trains to/from S_1, *D*, *E*, *F*, *G* are the switches directing trains to/from S_2, T_1, T_2 and T_3 stand for three trains and C is a switch on the track between S_1 and S_2 which can direct trains to a depot. Two typical switch malfunctions and the consequences are depicted as follows:

If T_1 is going to stop at S_2 but switch *D* suddenly cannot be pointed to D-S_2 direction, T_1 could run to switch *E* and then go backwards to S_2. In this case, a dispatcher only needs to reschedule the trains going into and out from the station, which is considered a trivial task.

If switch *C* cannot be correctly moved back after directing T_2 to the depot, T_3 will not be able to go S_2 as planned. In this situation, T_3 has to run backwards to S_1, where it can change to the "up" track. Also, all the downward trains after T_3 will change to use the "up" track from S_1 to S_2. In other words, there will be three flows of trains merging at S_1, S_2 and using the single "up" track between them. Thus, it may be hard for dispatcher to make decisions on rescheduling the affected trains.

The above two scenarios are representatives of the many possible switch failure scenarios, from which two types of rescheduling are abstracted. Since the first kind of rescheduling can be solved easily as stated, the discussion in this paper will focus on the second one. This kind of rescheduling task has a prominent difficulty, which is to solve the meet-pass of train flows coming from three different directions at affected stations as shown in Fig.8.

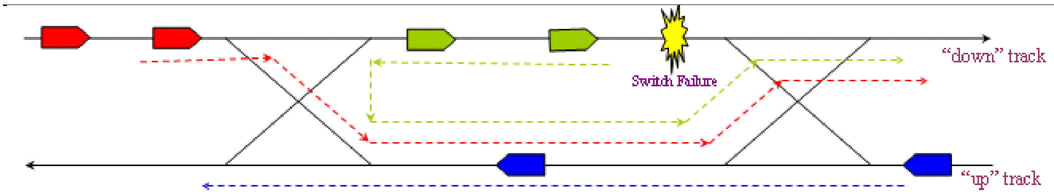


Fig.8. Illustration of three conflicting trains flows to be rescheduled.

Given the importance of train rescheduling in HSR operation, it has been widely studied by researchers all around the world. Commonly, a HSR consists of double/multiple tracks, other than single track as some freight lines. Thus, most of the research works on passenger train rescheduling focus on delay-triggered rescheduling with the objective to minimize the spread of delay, without caring about the meet-pass problem (1998, p. 390; Pacciarelli 2004). Recently, some researchers found that track would become unavailable in situations like maintenance possession and obstacle occurrence, which means double-track may turn to single-track in certain railroad section(Johanna 2006). However, neither of them considers the backward movement of trains, thereby only two train flows are handled.

This paper is organized as follows: Section 2 gives the model theory and method of rerouting and rescheduling problem introduced above. Meanwhile, we propose an optimization approach based on Constraint Programming (CP). Section 3 analyzes the result in comparison with a traditional approach. The conclusions and discussions are presented in Section 4.

Theory and Method

Train rescheduling during disturbances is a complex task in practice as well as in theory. There are two important challenges. The first is to model the disturbance situation into a practically viable representation of the problem. The second is to solve the problem so as to obtain a new schedule which is the most similar as possible to the original one within a reasonable time frame.

The existing train rescheduling models mostly schedule the arrival and departure time of trains based on their original track. This paper consider a backward movement of trains due to switch malfunction (two green trains run backwards to last station, then go forward on another negative direction “up” track as shown in Fig.2). Therefore, the rescheduling model in this situation is more complex and difficult.

Firstly, we denote the known data of trains and stations for a given timetable. There are m stations and n trains. Let S be the set of stations, $T1$ the set of trains need run backwards (green colour trains in Fig.2), $T2$ the set of trains don’t need run backwards but need change to another track (red colour trains in Fig.2) and $T3$ the set of trains run on a track as planned (blue colour trains in Fig.2), $T = T1 \cup T2 \cup T3$ the set of trains. We let index i be associated with a train and index j with a station.

Secondly, we define some basic definitions that are used in train rescheduling model formulation.

Minimum safety headways are the length of time or distance which two consecutive travelling trains are maintained to ensure safety.

- td is inter-arrival time.
- tf is inter-departure time.
- tz represents time interval between trains spaced by automatic block signals.
- tb_j represents time interval between two opposing trains arriving at station not at the same time.
- tfd_j, tdf_j represent safe time between two same directional consecutive trains’ arrival and departure.
- th_j represents time interval for two trains meeting at a station.

The parameter tq_{ij} specifies start-up additional time at station j for train $\boldsymbol{i}$, tt_{ij} specifies stop additional time at station j for train $\boldsymbol{i}$. The segment between two stations has minimum running time, ys_{ij} means minimum running time between station j and station $j+1$ for train $\boldsymbol{i}$. Because of passengers and freight service, trains are set minimum dwell time, ts_{ij} means minimum dwell time at station j for train $\boldsymbol{i}$. The parameter DFX_j specifies the capacity of station j. $w(i)$ represents the weight value of a train i. $c(i)$ represents the cost per time unit delay for train i which is a piecewise function.

In addition to above variables, we define a binary variable TC_{ij} as follows:

$$TC_{ij} = \begin{cases} 1 & if\ \ train\ i\ stops\ at\ station\ j,\ where\ i \in T, j \in S \\ 0 & otherwise \end{cases}$$

In formulating the trains rescheduling problem in a switch malfunction scenario, we assume the switch of station k on the downward track break down, which happens at t_0 and returns to normal until t_1. $XD_{ij}^{'}$ / $XF_{ij}^{'}$ are the arrival / departure time of train $\boldsymbol{i}$ at station j according to the original timetable.

Decision variables are of two types: time variables and sequence variables.

- Time variables XD_{ij} and XF_{ij} represent the arrival and departure time of train $\boldsymbol{i}$ at station j.
- Sequence variable $order_{i1,i2}^{j}$, if train $i1$ departs from station j in front of train $i2$, thus $order_{i1,i2}^{j} = 1$, otherwise $order_{i1,i2}^{j} = 0$.

The objective (1.1) is to minimize the total weighted sum of delay time. The objective (1.2) minimizes the total costs of delay trains in order to mitigate the consequences caused by switch malfunction. The mathematical model is formulated as follows:

Minimize:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} w(i) \times (XD_{ij} - XD_{ij}^{'}), \quad XD_{ij} - XD_{ij}^{'} \ge 0,\ i \in T,\ \ j \in S$$

(1.1)

$$\sum_{i=1}^{n}\sum_{j=1}^{m} c(i, \Delta XD_{ij}) \times \Delta XD_{ij},\ \Delta XD_{ij} = XD_{ij} - XD_{ij}^{'} \ge 0,\ \ i \in T,\ \ j \in S$$

(1.2)

Subject to:

$$XD_{i(k+1)} \ge t_0 + (t_0 - XF_{i(k+1)}^{'}),\ \ i \in T1$$

(2.1)

$$XD_{i2(k+1)} - XD_{i1(k+1)} \ge TC_{i1(k+1)} \times td + (1 - TC_{i1(k+1)}) \times tz,\ \ i1, i2 \in T1,\ \ order_{i2,i1}^{k+1'} = 1 \quad (2.2)$$

$$XF_{ij} \ge XF_{ij}^{'},\ \ i \in T,\ \ j \in S$$

(3)

$$XF_{ij} - XD_{ij} \ge TC_{ij} \times ts_{ij},\ \ i \in T,\ \ j \in S$$

(4)

$$XD_{i(j+1)} - XF_{ij} \geq ys_{ij} + TC_{ij} \times tq_{ij} + TC_{i(j+1)} \times tt_{i(j+1)}, \;\; i \in T3, \;\; j, j+1 \in S \qquad (5.1)$$

$$XD_{i(j-1)} - XF_{ij} \geq ys_{i(j-1)} + TC_{ij} \times tq_{ij} + TC_{i(j-1)} \times tt_{i(j-1)}, \;\; i \in T1 \cup T2, \;\; j, j-1 \in S \qquad (5.2)$$

$$\begin{cases} XF_{i2(j+1)} - XF_{i1(j+1)} \geq TC_{i2(j+1)} \times tf + (1 - TC_{i2(j+1)}) \times tz \\ XD_{i2j} - XD_{i1j} \geq TC_{i1j} \times td + (1 - TC_{i1j}) \times tz \end{cases}, \;\; i1, i2 \in T1 \cup T2, \;\; order_{i1,i2}^{j+1} = 1$$

(6.1)

$$\begin{cases} XF_{i2j} - XF_{i1j} \geq TC_{i2j} \times tf + (1 - TC_{i2j}) \times tz \\ XD_{i2(j+1)} - XD_{i1(j+1)} \geq TC_{i1(j+1)} \times td + (1 - TC_{i1(j+1)}) \times tz \end{cases}, \;\; i1, i2 \in T3, \;\; order_{i1,i2}^{j} = 1$$

(6.2)

$$XF_{i1j} - XD_{i2j} \geq tdf_j, \;\; i1, i2 \in T1 \cup T2 \text{ or } i1, i2 \in T3, \;\; j \in S, \;\; order_{i1,i2}^{j} = 1 \qquad (7.1)$$

$$XD_{i1j} - XF_{i2j} \geq tfd_j, \;\; i1, i2 \in T1 \cup T2 \text{ or } i1, i2 \in T3, \;\; j \in S, \;\; order_{i1,i2}^{j} = 0 \qquad (7.2)$$

$$\left| XD_{i2(k+1)} - XD_{i1(k+1)} \right| \geq tb_{(k+1)}, \;\; i1 \in T1 \cup T3, i2 \in T2$$

(8.1)

$$\left| XD_{i2k} - XD_{i1k} \right| \geq tb_k, \;\; i1 \in T1 \cup T2, i2 \in T3$$

(8.2)

$$| XF_{i1(k+1)} - XD_{i2(k+1)} | \geq th_{(k+1)}, \;\; i1 \in T1 \cup T2, i2 \in T3$$

(9.1)

$$| XF_{i1k} - XD_{i2k} | \geq th_k, \;\; i1 \in T1 \cup T2, i2 \in T3$$

(9.2)

$$\sum W(XD_{ij}, XF_{ij}, t) \leq DFX_j, \;\; i \in T, \;\; j \in S, \;\; W(x, y, t) = \begin{cases} 1 & x<t<y \\ 0 & t<x \text{ or } t>y \end{cases} \qquad (10)$$

Constraint (2) focuses on the train set $T1$, (2.1) says that the arrival time of each backwards train is later than a specified time which don't consider the operation time of backward travelling. (2.2) says that if the train $i2$ depart from station $k+1$ before the train $i1$, the adjacent trains which need run back to station $k+1$ must keep a safety headway when downward track breaks down. Constraint (3) says that if there is passenger service, the departure time of trains can't be earlier than the original departure time. Constraint (4) says that the time of a train stops at station must be greater or equal to minimum dwell time. Constraint (5) says that the trains must satisfy segment running time restriction. Constraint (6) compels two same directional consecutive trains to keep a specific distance in order to satisfy the tracing time restriction. Constraint

(7) says that two same directional consecutive trains must follow the "arrive-depart" and "depart-arrive" limitations to maintain safe operation. Constraint

(8) says that two opposing trains can’t arrive at a station at the same time. Constraint (9) says that the duration time of two opposing trains meeting must be greater or equal to th_j. Constraint (10) ensures that the quantity of trains stopping in a station must be less than capacity of this station.

To solve the above mathematical formulations, there are some difficulties: 1) Existing too many resources and safety-related constraints. 2) Some constraints are nonlinear. 3) Decision variables have too many alternatives, thus they are difficult to search better solutions. Constraint programming (CP) can be used to handle these issues. The reasons for choosing the CP approach to solve our problems are listed as follows (Snezana 2007):

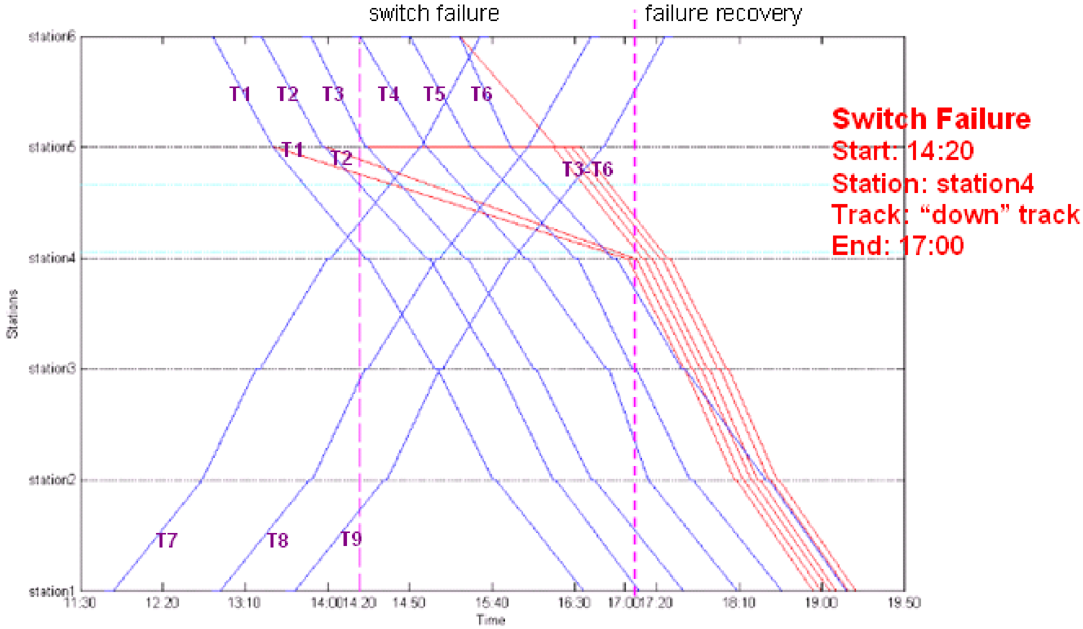
- Declarative nature of constraints in CP approach offers a comfort in formulating the numerous and complex constraints existing in train rescheduling problems.
- The presence of commercial CP tools, such as IBM ILOG Optimization Engine, may significantly shorten the development time and length of the programming code of scheduling applications.
- Possibility of dynamic modification of constraints set by adding new constraints in order to satisfy the current requirements.

As above mentioned, the CP approach which can reduce the gap between the problem description at a high level and algorithms implementation (1996, p. 170) has become an appealing technology for planning and rescheduling problem. However, how to solve the above train rescheduling model by CP approach in this paper? We code the constraint components and optimization objectives in OPL language. Furthermore, we can calculate rescheduled timetable quickly due to using IBM ILOG Optimization Engine.

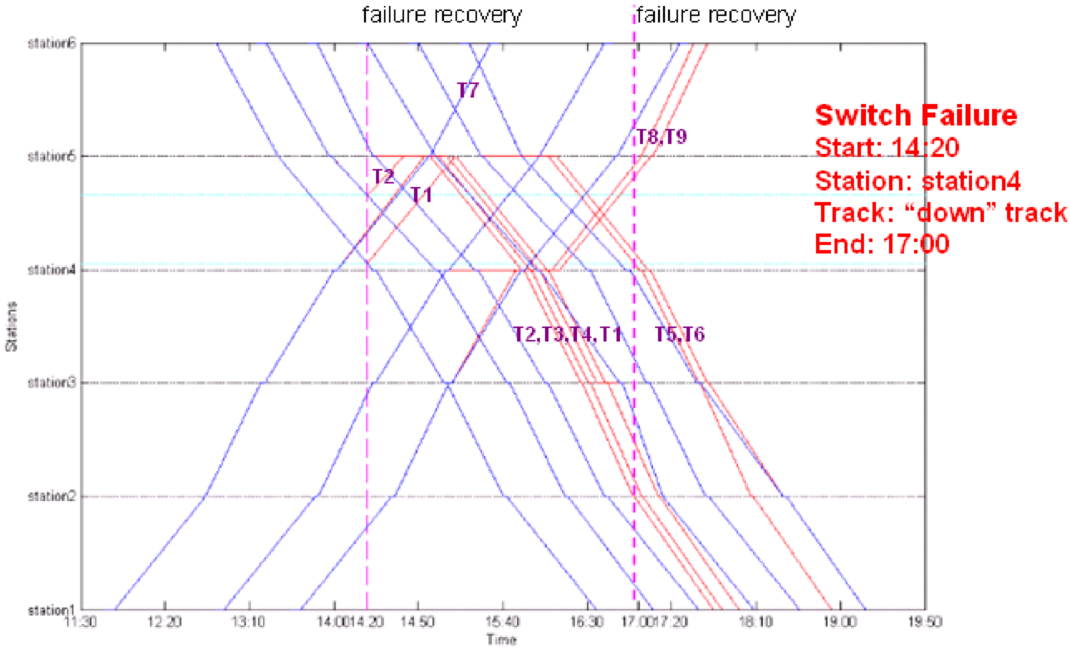
Results

Our computational experiment data source is abstracted from a real high speed railway operation from 11:30 to 19:30. A disturbance caused by switch malfunction happens at 14:20 when a downward train t1 is going to be pulled into Station 4. The failure is recovered at 17:00. There are two strategies to solve the problem: 1) First, the following downward trains of t1 don’t change their track. They maintain their order, waiting to travel until failure recovery. In this case, the upward trains aren’t affected, but the downward trains delay too long time (Ho 2006, p. 27). 2) Second, some trains need to run back to last station. Then they run on the “up” track. Meanwhile, some downward trains directly change to move on the “up” track as shown in Fig.2. Because of the long delay of trains in Strategy 1, we put emphasis on Strategy 2 in order to solve this problem.

We implement the two strategies using CP approach based on IBM ILOG optimization engine. The result is shown in Fig.3. the blue lines represent the original time-space diagram, the red lines represent the rescheduled time-space diagram. the magenta lines represent the start and end time of switch failure. In diagram (a), we can find that the upward trains T7-T9 aren’t affected and the downward trains T1-T6 have too long delay. In diagram (b), we can obviously observe that two downward trains T1-T2 run back to Station 5, the upward trains T8-T9 need delay some time. As the illustration shows that the result of strategy 2 appears better than strategy 1 as the average trains delay time of strategy 2 is less than strategy 1.



(a) Train time-space diagram of Strategy 1.



(b) Train time-space diagram of Strategy 2.

Fig.3. Train time-space diagram illustrate two alternative strategies.

In order to contrast results of two strategies, we calculate two objective functions of trains rescheduling using a standard configuration of ThinkPad X61(2.0GHz CPU, 1.98GB Memory), listed in Table 1. Values of Objective 1 are given in minutes, which mean the weighted sum of delays of all trains. Values of Objective 2 are given in p, which mean the total cost caused by delay trains. Besides, we also compare the running time of two strategies. Though the running time of Strategy1 is less than Strategy2, both of them are little, which can satisfy the real time requirement. From Table 1, we can find that Strategy 2 performs well for long delays according to the optimization criteria.

Table1. Experiment results using two strategies.

	Objective 1 value (min)	Objective 2 value (p)	Running time (sec)
Strategy 1	4291	10268	36
Strategy 2	1982	1856	41

Discussion

In this paper, we formulate a mathematical model characterized running backwards for trains rerouting and rescheduling in case of switch malfunction. Furthermore, we propose an approach, based on IBM ILOG, to solve the model. The new situation of trains running backwards first be taken into account, and experiment results in realistic scenario prove the feasibility and practicability of the solution.

It is only an attempt to solve the trains rescheduling problem. There are some limitations of current model. For example, how to design the circuit interlock constraints among switches? How to model the switch location and failure type? How to handle the dynamic feature of switch failure recovery time? All of them need to be studied in the future work.

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