THE NEW THINKING OF APPLICATION ON DEBRIS FLOW MONITORING

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ABSTRACT

The debris flow monitoring has been developed for many years in Taiwan. In the very beginning, the stable monitoring stations were set up for the monitoring mechanism. Then the mobile monitoring vehicles were developed later on in the middle stage of monitoring development. Now the emphasis of monitoring fields is on the application of mobile monitoring. There're 14 stable monitoring stations and 2 mobile monitoring vehicles were built since 2002, while the low-cost, widely distributable WSN monitoring modules are invented in 2007 via WSN technologies. A portable monitoring station is invented to construct a comprehensive monitoring network through widely-range equipped monitoring instruments. The monitoring network can collect the real time data and analyze the energy variation before, during, and after the debris flows occurred, and it helps to build up an alert mechanism. Meanwhile, all the monitoring or alert information is released from the announcement platform in OGC-SWE standard format to enhance the efficiency of decision making in disaster mitigation.

Key Words: Debris flow monitoring, Wireless sensor networks, Sensor observation service

INTRODUCTION

The debris flow is a tremendous threat to humans' living environment and safety. The landforms and geologic structure in Taiwan are peculiar, and terrains are easily broken and unstable. Washout and rainstorms which result in debris flows and landslides in mountain areas occur frequently during the typhoon season. To protect inhabitant's life and properties, scholars and precaution agencies continuously search for the cause of debris flow occurrence and try to build a preventive mechanism. Since2002, the government in Taiwan had devoted much effort on monitoring and investigation for the debris flows. Several monitoring stations and equipments are set up to observe, receive and transfer data to disaster management center. The real-time observation data transferred back to the central server via satellite communication network. It allows relevant personnel to grasp the real-time spot situation of every monitoring station during the typhoon season.

DEBRIS FLOW MONITORING IN TAIWAN

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Debris flows are flowing mixtures of mud, sand, rock, and water that move downward along the slope terrains or gullies under the force of gravity. When debris flows occur, a torrent of soil, sand, and rocks gushes down the creeks and forms alluvial depositions in the valley, posing a hazard to human lives and properties and causing severe damages to the ecological environment. In recent years, in order to precisely monitor the hydrological conditions during a debris flow event, the government in Taiwan establishes various debris flow monitoring stations in high risk areas, each with advanced monitoring instruments to collect on-site debris flow information in Taiwan. There are 13 debris flow monitoring stations had been built, the main purpose of the station is to correct observation data and monitor the event of debris flow in real time. The advanced monitoring instruments include rain gauge, wire sensor, geophone, ultrasonic water level meter, and infrared CCD camera. The information detected by the sensors mentioned above can improve the accuracy of the debris flow alert model based on rainfall thresholds.

By using advanced monitoring instruments and highly efficient transmission systems, the debris flow monitoring stations conduct real-time monitoring on potential debris flow torrents. During typhoon period, instruments at the debris flow monitoring stations are employed to collect all-weather real-time information. By making use of the satellite transmission to overcome the limitations of topography and weather, the monitoring system can transmit field information to the emergency response system, which will then instantly display images and information via the internet to provide information to the decision-making authorities. Fig. 1 is a map of 13 monitoring stations' position. Fig. 2 is images of monitoring instruments. Fig. 3 is architecture of debris flow monitoring system.

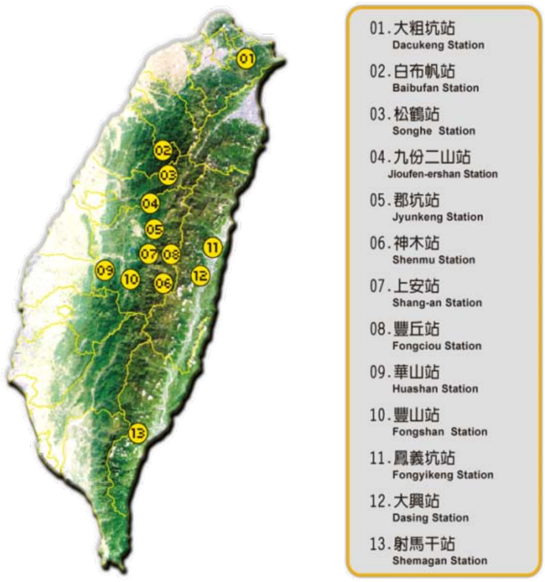

Fig. 1 position of 13 monitoring stations

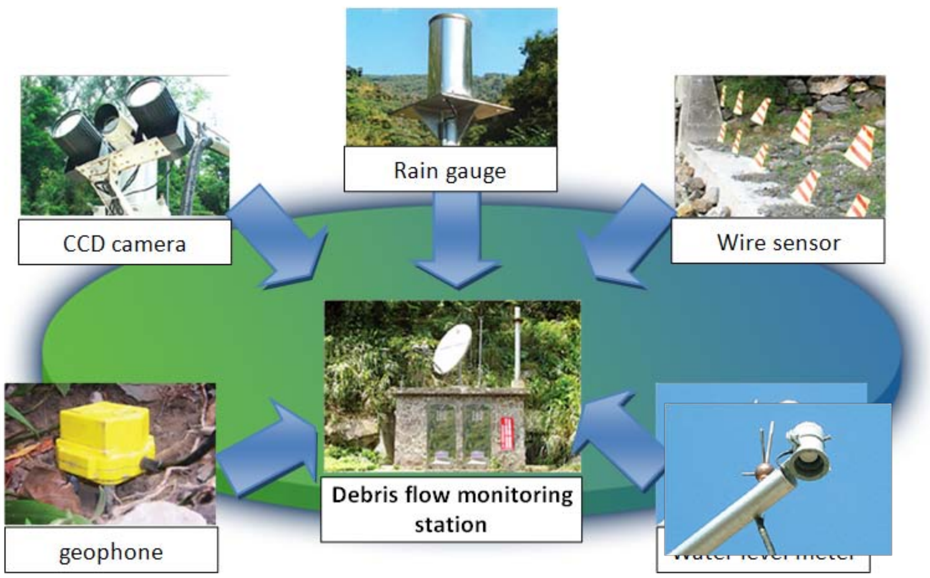

Fig. 2 instruments in monitoring station

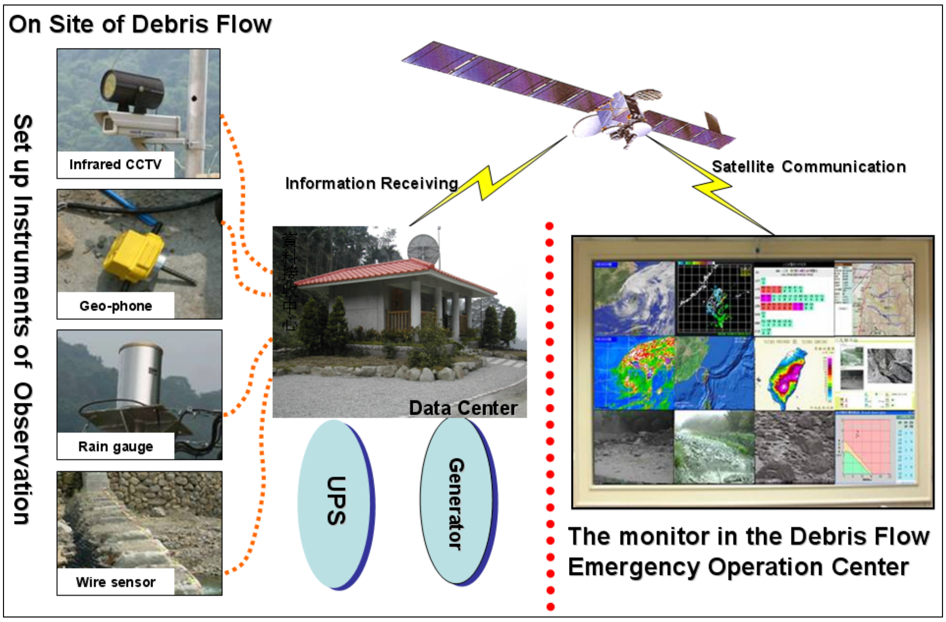

Fig. 3 architecture of debris flow monitoring station

EXTENDING MONITORING SCALE FOR DEBRIS FLOW

In order to extend the scale of observation, 2 mobile debris flow monitoring stations had been built in 2004. The advantages of employing the mobile debris flow monitoring stations are reducing the construction and maintenance cost effectively, and mobility is better than fixed monitoring stations. Fig. 4 is a mobile monitoring station. Fig. 5 is architecture of the mobile monitoring station; instruments in the mobile monitoring station include rain gauge, CCD camera, IR lamp, IT system, power system and satellite. The mobile station transmits observation data through satellite communication, and then the debris flow emergency operation center can receive data from mobile stations in real time.

Fig. 4 the mobile monitoring station

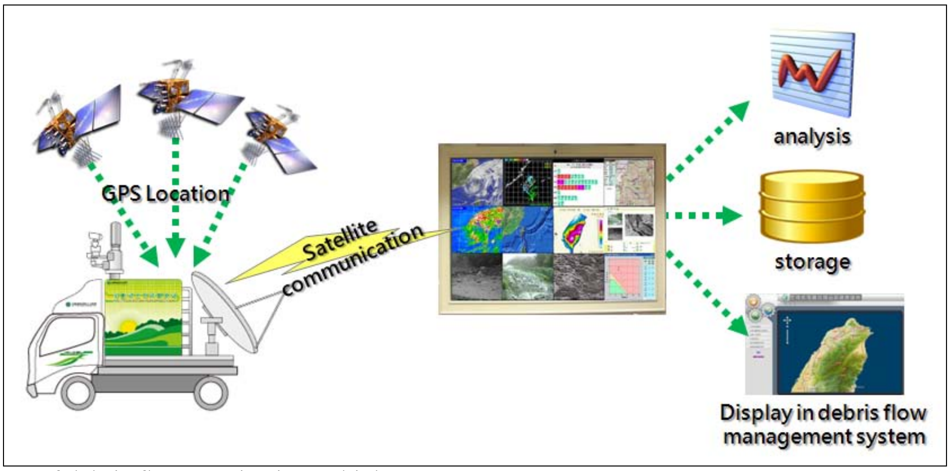

Fig. 5 architect of debris flow monitoring vehicle

Current monitoring stations mostly provide indirect measurement; it detects the presence of debris flows. Other measurement such as speed, volume and density can't be easily captured by monitoring station. For this reason, since 2007 we started to research techniques of wireless sensor network (WSN), and development a new instrument "Smart Cone Frustum" for in-situ observation and tracking of debris flow in real-time. Fig. 6 is the sketch of "Smart Cone Frustum"; fig. 7 is a sample of "Smart Cone Frustum". "Smart Cone Frustum" has be installed a mobile wireless sensor with rugged plastic hosing. It can be deployed to sit on the riverbed and stay stationary in water. When debris flows occur, "Smart Cone Frustum" will be floating and moving with debris flows. Receiver gets GPS location and velocity from WSN during debris flow event. The advantages of "Smart Cone Frustum" are low cost and high mobility; "Smart Cone Frustum" can be spread in the river. Lots of Smart Cone Frustums turn into a network that can provide complete observation information in a region of interesting.

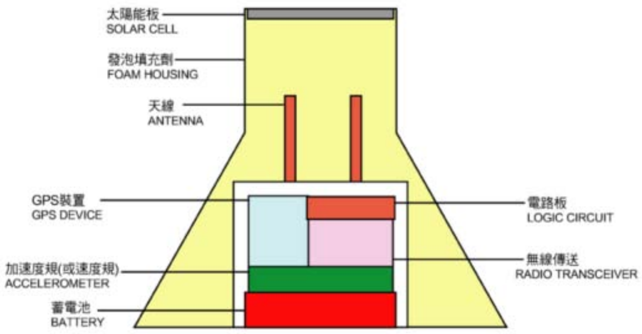

Fig. 6 sketch of "Smart Cone Frustum"

Fig. 7 "Smart Cone Frustum"

INTEGRATION AND STANDARDIZATION

There are 13 fixed stations, 2 mobile stations and large number of wireless sensors for debris flow monitoring. All of the stations have least 400 sensors, sensors are everywhere, and how to integrate different kind of sensors into a platform is an important issue. For the reason, we try to use the sensor web enablement framework that proposed by Open Geospatial Consortium and develop a platform for all observation sensors.

A. *The Background of OGC*

The Open Geospatial Consortium (OGC) is a non-profit, international, voluntary consensus standards organization that is leading the development of standards for geospatial and location based services. The OGC specifies several standards for data retrieval, data visualization and data processing. The presented debris flow demo scenario workflow uses OGC Sensor Web Enablement and OGC Web Processing Service technologies for delivering and processing of dynamic sensor data streams. Grid Computing was utilized for increasing the performance of processing large amounts of dynamic geospatial data. This chapter provides a brief overview of the fundamental concepts behind the presented approach.

B. *Sensor Web Enablement*

A sensor network is a computer accessible network of spatially distributed devices using sensors to monitor conditions at different locations. The OGC Sensor Web Enablement (SWE) framework of open standards presents many opportunities for adding real-time sensor data to the internet. Within the SWE framework, the enablement of such sensor webs and networks is being pursued through the establishment of several encodings for describing sensors and sensor observations, and through several standard interface definitions for web services.
Beside other specifications from within the OGC SWE framework, the Sensor Observations Service (SOS) is a standard for requesting, filtering, and retrieving observations and sensor system information through a Web Service interface. The SOS is the intermediary between a client and an observation repository or near real-time sensor channel. Fig. 8 is the concept of sensor web enablement.

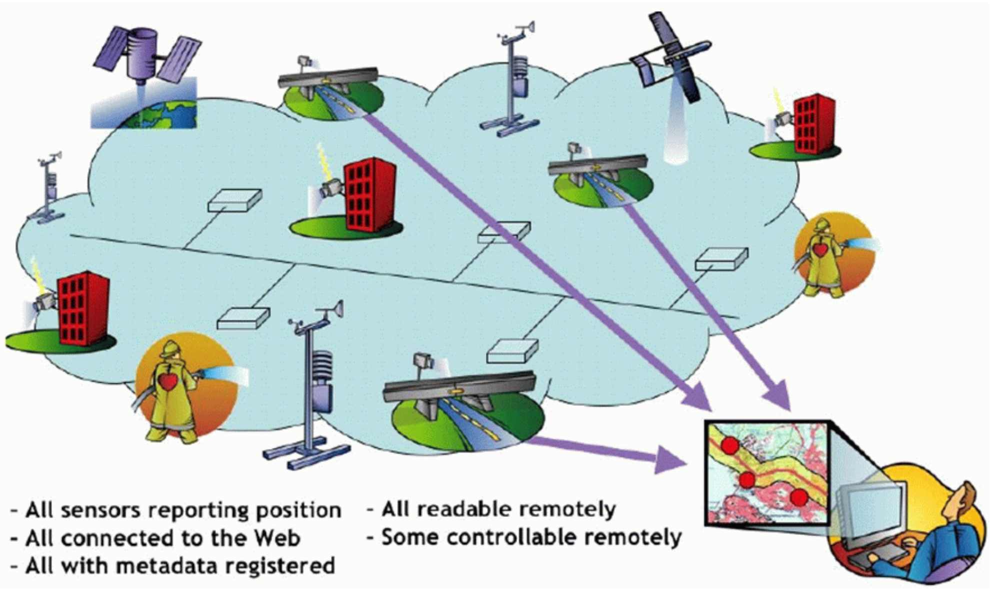

Fig. 8 concept of sensor web enablement

Service Oriented Architecture (SOA) was proposed by Gartner in 1996; the main concepts of this architecture are loosely coupling and components reusability, in order to facing a various changes business environment. The general idea of SOA is to drive software to a high flexibility, scalability, extensibility and plug-and-play architecture without modifying legacy systems "hugely". Conforming to open standard is also the main concept for adopting SOA into an organization.

C. Information Integration from Sensor Observation Service(SOS)

In the proposed Service Oriented Architecture (SOA) based debris flow monitoring architecture a SOS is used to serve the measured rainfall and ground vibration data for later processing through the Web Processing Service (WPS). The debris flow monitoring system implements the “GetCapabilities”, “DescribeSensor”, and “GetObservation” three components of operations in SOS. “GetCapabilities” is one of the operations that allow clients to retrieve service metadata about a specific service instance. No “request” parameter is included, since the element name specifies the specific operation. “DescribeSensor” obtains metadata that describe the characteristic of an observation procedure (sensor or sensor constellation) is to retrieve it from a catalog. However, a catalog may only contain high-level information about the observable properties, locations, contact information, etc. The “GetObservation” operation is designed to query a service to retrieve observation data structured according to the “Observation and Measure” specification. Upon receiving a “GetObservation” request, a SOS shall either satisfy the request or return an exception report. Fig. 9 is architecture of debris flow monitoring system in Sensor Web Enablement (SWE) framework; sensors which are installed in the monitoring station call operation “InserObservation”, and send observation to SWE server through internet communication. Other applications can connect to SWE server and use “GetObservation” operation, “GetCapability” operation, or “DescribeSensor” operation to get observation information, service capabilities or sensor capabilities from SOS operations. Fig. 10 is sequence diagram of Sensor Observation Service; the procedures of SOS are shown in this picture.

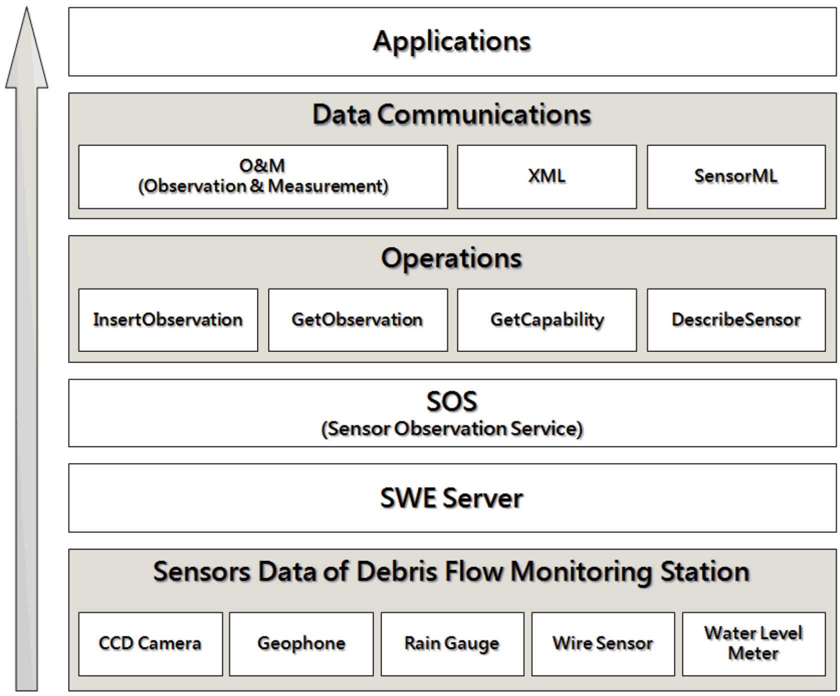

Fig. 9 system architecture

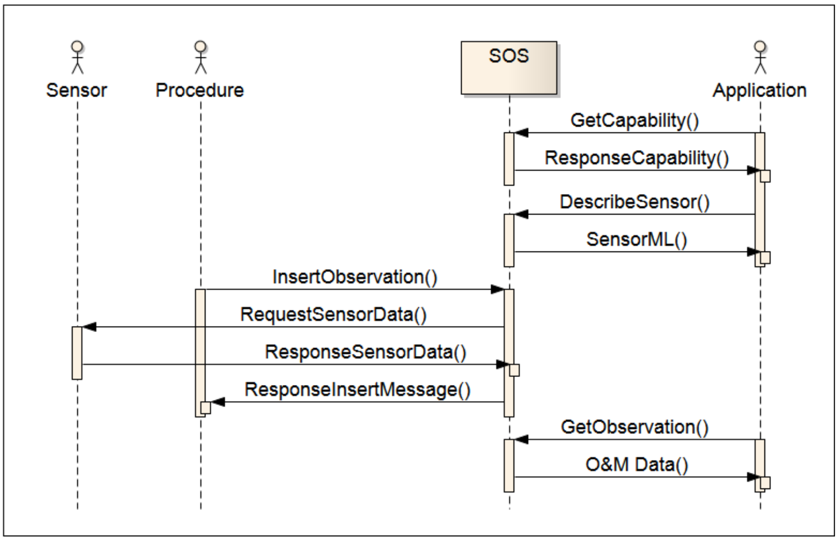

Fig. 10 sequence diagram of Sensor Observation Service

Fig. 11 debris flow monitoring system based on Google earth

Fig. 12 request and response of “GetObservation” operation

CONCLUSION

Within the SWE initiative, the enablement of such sensor webs and networks is being pursued through the establishment of several encodings for describing sensors and sensor observations, and through several standard interface definitions for web services. Sensor Web Enablement standards that have been built and prototyped include Observations & Measurements Schema, Sensor Model Language, Sensor Observations Service, Sensor Planning Service, Sensor Alert Service. The goal of SWE is to enable all types of Web and Internet-accessible sensors, instruments, and imaging devices to be accessible and, where applicable, controllable via the Web. The vision is to define and approve the standards foundation for "plug-and-play" Web-based sensor networks. Using SWE framework can enable interoperability within communities between different sensor types, disciplines, sciences and agencies, using SWE framework can break the bottleneck of data communication and encourage interoperability between different locations and organizations.

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