Structuring of Knowledge - a New Application for M2M in Earth Observation from the Space

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Abstract

Next year 2012, is the 20th anniversary of the 1st Earth Summit that was held in Rio de Janeiro in 1992. The international mechanisms for conserving the Earth proposed there, such as the reduction of Greenhouse Gas (GHG) emissions and the conservation of biodiversity have tended to diversify the range of commercial activity. The future calls not for measures that are confined exclusively to an enterprise, region or nation, but for those that are applicable on a global scale. With such measures, the fundamentals can be summarized into the three layers of "observation," "analysis" and "proposal and execution of the actual measures." M2M can act as a platform for processing these three layers within the framework of the ICT (Information and communications technology) infrastructures. This paper discusses the new values that will be added in the automation and integration of global-scale "observations" and "analyses" by combining the extensive spatial sensor technology owned by NEC with the M2M technologies.

Keywords

observation satellite, global environment, image processing, knowledge structuring, multivariate analysis

1. Introduction

Since the enactment of the Basic Law on the Promotion of the Use of Geographical Information on May 23, 2007, the Japanese Government has actively been promoting the construction of the NSDI (National Spatial Data Infrastructure) that can utilize geospatial information from multiple aspects. One of the issues of this new data focused infrastructure is that of satellite positioning. The release of new services utilizing accurate positional information from the GPS satellites and quasi-zenith satellite "MICHIBIKI (QZS-1)" are projected for the future. However, it is not our aim in this paper to discuss the function of M2M in the positioning information services. As this field has already been participated by many enterprises and although we are aware that their endeavors include not a few scenarios in which M2M might be applicable we intend to consider these in detail on another occasion.

Before reading this paper, the reader is recommended to refer to the papers on the history of NEC's Science and Technology satellites beginning with Japan's first satellite "OSUMI" and the uses of satellite data that are expected to expand in the future. These papers were published in NEC Technical Journal Vol. 6, No. 1 (April, 2011), "Special Issue on Space Systems." This issue also included papers on NEC's roadmaps for satellites and their featured earth observation sensors as well as on the technologies for data image processing. **Fig. 1** shows an example of image information obtained from an earth observation sensor. This is the data for calculating the water temperatures of the ocean surface around the Japanese

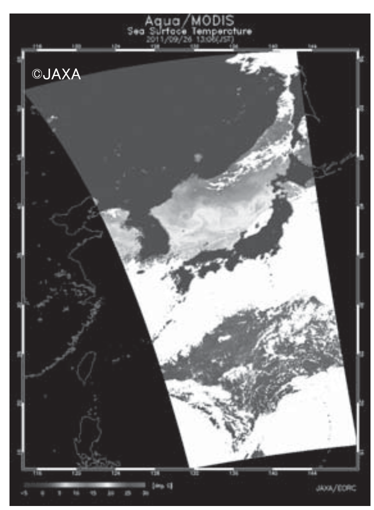


Fig. 1 An image shot by the earth observation satellite depicting ocean surface temperatures around Japan.

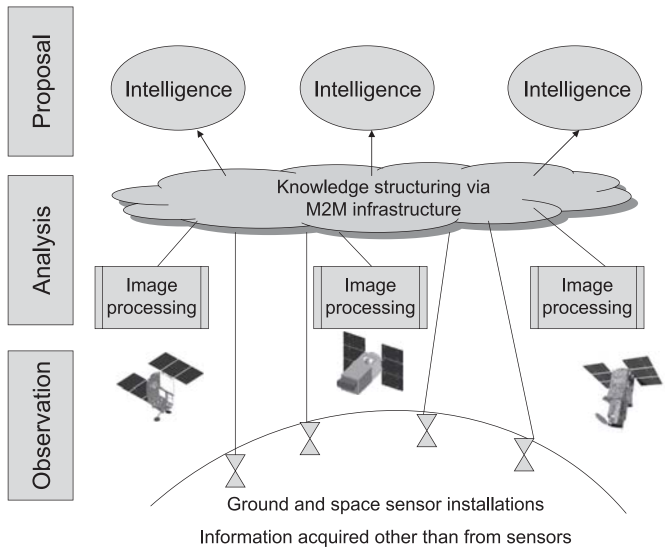


Fig. 2 Knowledge structuring via M2M.

Archipelago, showing clearly the movement of ocean currents such as the KUROSHIO and OYASHIO streams.

At NEC, we have had nearly half a century of history of development of satellite-borne sensors. A large number of NEC-made sensors have already been installed and operated on Japanese satellites as well as on those of overseas countries. In the future, it is expected that improved performances and reductions in the sizes of the sensors will lead to improved resolution and to a decrease in the cost of information obtained from the observation satellites. As a result, the information will be affordable for general business activities in providing new “viewpoints” that can complement and supplement the information obtained from various ground-installed sensors.

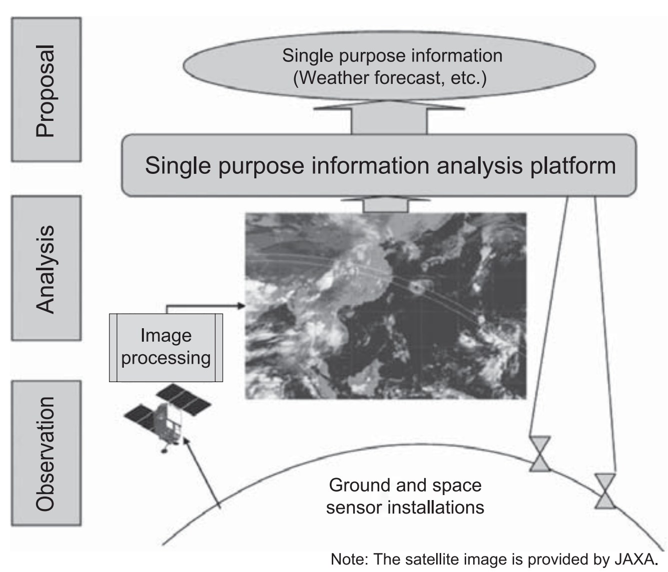
Information obtained from satellites like that from any sensor is valuable in itself. However, in order to further improve the value of such information, it is important to enhance the information to the level of intelligence by means of applying the three layers of “observation,” “analysis” and “proposal (**Fig. 2**). This is what is called “knowledge structuring.” The CONNEXIVE M2M platform has the potential to a certain degree of becoming a powerful tool for automating the conversion of information into intelligence, or of performing knowledge structuring.

Before studying how the information from satellites can be converted into intelligence, let us review the world without the M2M platform.

2. Vertical Integration of Data and Its Limits

As seen with the “HIMAWARI” Geostationary Metrological Satellites with which we are familiar in TV weather forecasts, earth resources technology satellites and the spy satellites that we often see in movies, many of the observation satellites are developed as dedicated satellites for the purpose of observation. With each of these types of satellites, the cause-and-effect relationship is clear because the target → observation equipment → data collection methods → data analysis techniques are in a linear relationship. Naturally, the three layers of “observation,” “analysis” and “proposal” do exist in a world in which data is integrated in this manner in the vertical direction. For instance, with the weather forecast, the meteorological satellite observes features such as the movements of clouds and the temperature distribution in the skies high above a broad area. The information thereby observed from various ground-installed sensors; such as atmospheric pressure, temperature, humidity and precipitation is then arranged in order to create a database called a “meteorological chart.” When the “analysis” of the forecasters is added to this data, it becomes a “proposal,” which is the weather forecast (**Fig. 3**).

As seen above, while the collection and use of data is enclosed in a vertically integrated world (information silo) in which the cause-and-effect relationship is clear, there is no



Note: The satellite image is provided by JAXA.

Fig. 3 Vertical integration of data.

need for a connection of the silos in the horizontal directions. However, in case a need for "data utilization" emerges, for example when a convenience store manager references the weather forecast before deciding on a purchase to augment a stock of lunches etc., the information enclosed within a silo cannot serve as a solution of this need. What the store manager needs is not only the local forecast of the area in which he or she lives, but also the ability to compare the next day's forecast with past data. For example, if the next day is the field day of a nearby elementary school, he or she needs to know the temperature change over the day in the local area as well as the weather and humidity tendencies of similar cases in the past. In addition to the weather forecast, the store manager performs "analysis" of various data such as the vacancy rates of nearby apartment houses obtained from real-estate agents and the selections available at competing stores before reaching a final "proposal" that is the lunch order quantity. Thus the convenience store manager has created intelligence by combining a large variety of information in addition to the weather forecast. This is precisely a form of knowledge structuring, and this is the point at which the knowledge structure is important in the utilization of data.

3. Knowledge Structuring by M2M

The basic structure of M2M is to connect the gateway layer and service layer via a network. The gateway layer has various sensors connected to it so that it is capable of provisioning (setting changes). In addition, it is also connected to various input/output devices via an intelligent agent and is capable of optimizing output information according to the image resolution of the terminals. The service layer, which is connected to the gate layer via the network has an open API of service type and can incorporate applications for services such as home automation, agricultural ICT, medical treatment, nursing care, etc.

Now let us examine knowledge structuring including satellite data by taking the agricultural ICT as an example. When considering the automation of agriculture in a vast farmland context, its irrigation may be the case that is easiest to understand. It would be possible in regions without precipitation forecasts (**Fig. 4**) to develop a mechanism that measures the precipitation areas under clouds using the NEC-original precipitation radar. The weather forecast information might then be combined with the precipitation information in order to operate auto sprinkler systems at the required timings.

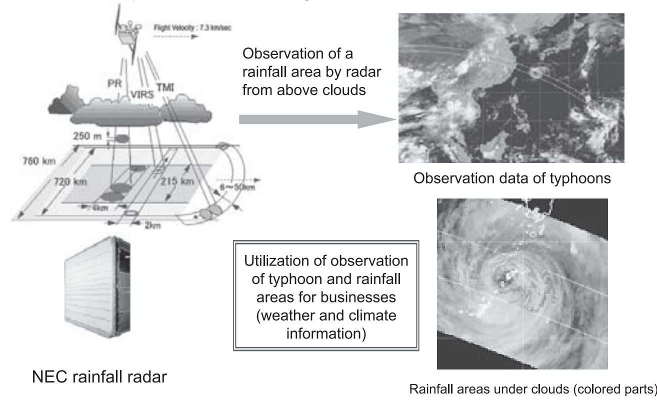


Fig. 4 Rainfall observation satellite and precipitation radar.

It would also be possible to measure the maturity of each crop using hyper-spectrum sensors and to harvest any harvestable crops before an approaching hurricane in order to minimize damage to the crop. There is also further potential merit in satellite use for unmanned agricultural work by using automated cultivators and combines that incorporate GPS receivers. This topic will be discussed in more detail in another paper.

As seen above, knowledge structuring is possible by collecting and analyzing data and control of multiple information silos, such as sensor information, meteorological information and auto sprinklers and by connecting them to external services via open API (Application programming interface) using suitably developed algorithms. We will now consider how the information obtained by observing the earth from space can be combined with the information from other information silos in order to provide "intelligence."

4. Considerations Regarding Automation via M2M

One of the benefits offered by ICT (Information and Communication Technology) is the automation of information processing by adopting mathematical techniques including statistics. Digitalization of a variety of analog data such as precipitation and ground surface temperatures via sensors has enabled the instantaneous processing of a large amount of data obtained from over a broad area. At the same time, digitalization has also made it possible to archive a large amount of data, mainly composed of images obtained from observation satellites for long periods and to apply techniques such as multivariate analysis. Below we discuss the linkages between the M2M and satellite information from the three viewpoints of coordinate axes, spatial axis and time axis.

4.1 Linkage on the Coordinate Axes (X–Y Axes)

The technology for computerizing the map information into electronic data and linking it with a car navigation system or guide map is called the GIS (Geographic Information System). This technology has a history of more than 40 years and the information obtained from satellites is already introduced via GIS. Attempts for encoding GIS information into XML are underway to facilitate linkage with more kinds of data. However, because the functions required for maps vary depending on their purpose, to achieve unification of all the systems continues to be challenging for the present. For example, as seen with many individual differences between countries observed in tag descriptions and even between the governmental ministries and agencies in Japan. As a result, we have formed the concept that new meanings can be created for relationships between existing data by linking multiple XML tags based on coordinate axis information by using M2M to construct a DOM (Document Object Model) (**Fig. 5**). For example, although this is an extreme example of application, it would be possible to link the cereal crop estimate of the Ministry of Agriculture, Forestry and Fisheries with the regional economic index data of a Bank of Japan branch managers meeting. It would thereby be possible to use the latest plant growth data obtained from the Hyper Spectrum Sensors developed by NEC to

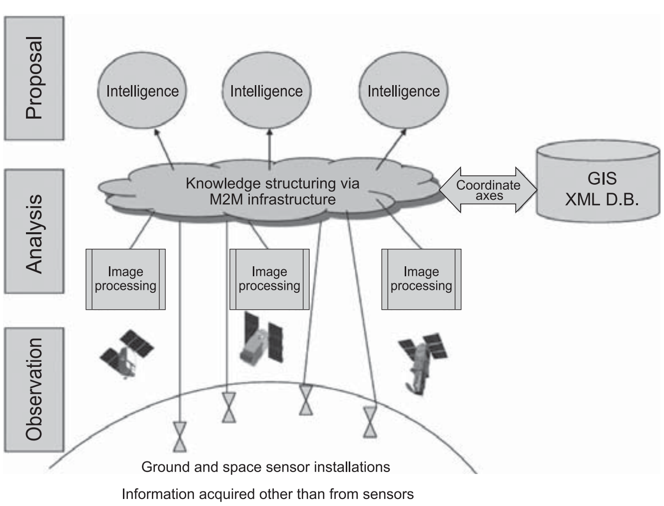


Fig. 5 Linkages on the X-Y axes.

promote the automatic selling/buying of municipal bonds of a specific region.

4.2 Linkages on the Spatial Axis (Z–axis)

The satellite-borne SAR (Synthetic Aperture Radar) is capable of detecting long term changes in altitude of a few centimeters over a half or one year. It is also possible at present to obtain accurate altitude information by applying image-processing technologies to stereo images captured via visible rays. XML data in which the altitude information obtained as described above to which the latitude and longitude information is added may be used as reference data. In this case processing the changes between near-real-time data such as the latest image sensing via satellites and LIDAR (Light Detection and Ranging) information from airplanes on an analysis application by means of M2M may serve many purposes. These include issuing of civil engineering and topography related alarms about the sagging and swelling of roads caused by subway work and changes in ground profiles resulting from volcanic activity. Furthermore, efficiency improvements and automation of the detection of illegally parked vehicles and measurements of tree growth after planting may also be implemented.

4.3 Linkage on the Time Axis

In the above, we considered the merits of extracting changes in the XML information related to coordinate axes and height by means of M2M. Now let us assume a situation in which such data is archived at constant time intervals. In other words, when the XML version of the GIS data of a location is arranged along the time axis, it is easy to review the changes up until the present as well as to predict the orientation of future changes. Nevertheless, as resolutions of the archived data vary greatly because of technological advances, it becomes necessary to align them using super-resolution technologies to a level that can meet the requirements of the latest display devices. Although the ideal would be to turn all of the archived resolution data into super-resolution data, the costs of the conversion would be very high in addition to that of the archiving. This could make it necessary to select only the actually required images with M2M and turn their resolutions into super-resolution on a charged basis. One of the possible applications of such a linkage procedure would be for verifying future forecasts obtained by analyzing archived satellite image data. For example, by detecting the water level of wells in a certain region using ground-installed sensors and comparing the results with the future forecast data via M2M.

5. Conclusion

The use of information obtained from observation satellites for purposes other than GIS and position information acquisition is still at the development stage. It is expected that observation satellites will reduce in size and improve their performances in the coming decade. Meanwhile, wider dissemination of M2M is also expected in the future. As the amount of digitized information increases, the algorithms linking different kinds of information will tend to expand in geometric progression or at an even higher rate. This will lead inevitably to further advancements in knowledge structuring procedures.

Reference

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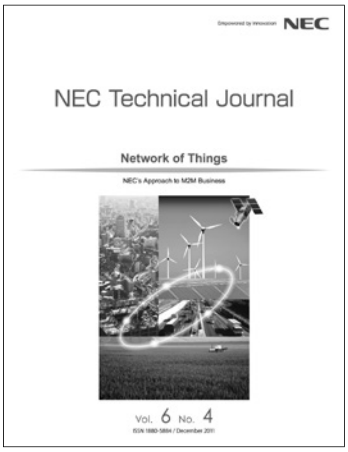

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