Summary

Because a wide range of information can be gathered from video data, the Ministry of Land, Infrastructure and Transport (MLIT) makes use of them to effectively control or manage roads and rivers. However, video data requires considerable network resources. Moreover, since it was locally treated over plurality, unification was very difficult. This paper describes technical study and review of the video data sharing system constructed by the MLIT.

Background

The MLIT has studied to standardize specifications of video data sharing systems on optic fiber networks, which are expected to serve as one of criteria for operations and management. Introducing Internet Protocol technology into the optic fiber networks of local regional work offices in fiscal year 2002, the National Institute for Land and Infrastructure Management of MLIT has verified video data sharing test system to deal with several video data in an unified format. The video data, compared to text data written by HTML, inherently requires a larger volume of network capacity.

The large volume IP integrated network was completed by use of WDM technologies in fiscal year 2003, as is shown in Figure 1. On top of that, IP technologies has introduced to 12,000 camera units of MLIT for road and river management. As a result, this network added an impetus toward the standardization which would promote nationwide use of the video data sharing system.
Study Approach

Technological Review

Integrated IP network
The MLIT has developed integrated optic fiber cable networks using Wavelength Division Multiplexing technologies to make effective use of optic fiber cables across the country. In order to maximize availability of optic fibers vulnerable to damages caused by such disasters as earthquakes, the optic fiber networks incorporate looping configurations, and use Resilient Packet Ring (IEEE802.17) which allows protection switching to be conducted on the order of milliseconds to secure high reliability. Additionally, a router (or Layer 3 Switch, both are comprehensively referred to as ‘router’ hereinafter) has reviewed to detour a microwave circuit, or even on satellite circuit with Internet Protocol.

IP Multicast
Recently, a significant volume of data transferred in the internet includes live images, audio content, or on-demand services. The technology to support these services receives and reproduces data simultaneously, not reproducing after having received and restored all data, and is referred to as ‘streaming’.

In the generic distribution approach, ‘streaming’ uses ‘unicast’ (an individual stream is
prepared for each receiver system), whereby the cache servers are deployed in order to
decrease traffic. Conversely, ‘multi-cast’ is another approach to decrease image data stream in the network. A stream is duplicated at each network node as required, thus avoiding an identical image traffic on a link, even when a couple of terminals or sites request the same visual data at a time.

Figure 2 illustrates the flow of each image data in unicast, cache server placement and multicast. Table 1 indicates the maximum traffic volume (stream figures) in each link. The \( \Phi \) and \( \delta \) represent the number of routers and the receiver systems linked with routers respectively.

![Figure 2. Image Data Distribution Structure](image)

<table>
<thead>
<tr>
<th>The distribution method</th>
<th>Traffic</th>
<th>The number of the maximum sending-out streams of an encoder</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>link1</td>
<td>link2</td>
</tr>
<tr>
<td>Unicast</td>
<td>( \times \Phi \times \delta )</td>
<td>( \times \delta )</td>
</tr>
<tr>
<td>Cache Server* Unicast</td>
<td>( \times \Phi )</td>
<td></td>
</tr>
<tr>
<td>Multicast</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These results indicate that streaming distribution requires coping with various level of routers, and any incentives to alleviate the load on networks does not factor in, which provides a reason to suppress multicast to be prevailing. However, by employing a server that is genuinely information system technology, future extension or improvement will be required, particularly when a modification in image encoding methods or system re-compositions (additional camera placement) are made.

A multicast uses network technology, thus avoiding any influence of changes in an application. The networking among jurisdictions of the MLIT can be defined within the device.
specifications. On balance, the multicast is employed due to superiority in future-expansion and cost saving effects.

**IP Multicast Route Control Protocol**

Protocol Independent Multicasting (PIM) was chosen for IP multicast route control protocol based on the degree of the product accomplishment, the status of RFC, use cases, and attributes of the approach (independent from unicast route control protocol). PIM is able to select a route for IP, irrespective of a route control mechanism offered by IP unicast packet as a platform. PIM consists of two modes: Spares Mode and Dense Mode. A case of traffic ‘flooding’ in PIM-DM happens when the volume exceeds an acceptable level for the network, resulting in an overload on router. However, PIM-SM is cumbersome for placing Rendezvous Point (RP) tapping of multicast data and Boot Strap Router (BSR) integrating location data of RPs, and there is no reason to dismiss route control protocols from the system. The above discussion leads to a conclusion that PIM-SM (RFC2362) is suitable to the system.

**Encoding Mechanism**

A digitizing process on visual images, referred to as ‘image encoding’, has been subject to standardization with the aim to achieve interoperability in CCITT (ITU-T incumbent). This has put significant emphasis on interactive communications among various vendors (for which ISO is currently responsible). MLIT has long employed image encoding ‘H.261’, which was standardized before the standard MPEG-2. The scope of each image coding mechanism application and the year when the standard was established are indicated in Figure 3.

![Figure 3. Application Scope of Image Encoding and Time When Standard was Set Up](image)

A term ‘international standard’ conjures up an image of a conformed system which is readily interoperable among others. In reality, MPEGx is an amalgam of elemental technologies, each of which has been standardized, and it provides a vendor with choices in their product designs.
at their will. MPEG-4 consists of MPEG-4visual, MPEG-4Audio and MPEG-4system, which defines multiplicity, and each one offers some choices as alternatives. One example is the widely used Windows Media Technology (Microsoft Co.), which employs MPEG-4Visual and also ASF (Advanced Streaming Format), equivalent to MPEG-4System. However, the MPEG-4version2 defines the file format, MP4 for MPEG-4System, and transmissions and controls are designed to be independent from the defined format. The image encoding for the system conforms to the international standards, MPEGx, on the ground of the given connectivity and proper procurement.

**Visual Image Data Sharing System Building**

**Visual image data sharing system**
The visual image data sharing system is a system to allow a PC of a client or an IP decoder to select and receive MPEG stream of monitoring camera images which are distributed through IP multicast from IP encoder and eventually displays them. This system enables required condition data by each client to be gathered in a matter of seconds. The visual image data sharing system embraces a metadata control server to control various data (metadata) from image sources (monitoring cameras), such as locations, name, device types and others.

![Figure 4. Visual Image Data Sharing System: as image display](image)

**Review on Distributed Metadata Control Server and Synchronization Approach**
Reviews on the distributed metadata control servers and on their synchronization are reviewed in order to achieve visual image data sharing system using monitoring cameras along roads and rivers across the nation.

**Review of the functions of distributed servers**
The data process is efficiently executed through separately located functions by data types identified for operations in the visual image data sharing system. The primary function
ranges from metadata control, to Web display control, and to static image control. Calculating the required time for a response, the expected processing capacity of a server and the backups for a failure, this two-tier structure is configured to link a regional office with a work office. Each server illustrated in Figure 5 requires a registration, update, reference, and a synchronized process among the separate servers in order to secure consistency and integrity of the database.

Figure 5. Synchronized Operations Among Each Server

Communication interface definition
Figure 6 shows a standard interface for metadata communication, which uses a general purpose technology, XML (Extensible Markup Language). Additionally, each of data items were unified in XML by defining schema and sentence structures. Figure 7 shows an instance of IP encoder in XML.

Figure 6. Conceptual Image of System Integration
<xml version="1.0" encoding="UTF-8"?>
<EncoderInf>
  <Encoder id="500001">
    <Enc_EstabLoc> CHUBU REGIONAL BUREAU </Enc_EstabLoc>
    <Enc_Name> CHUBU REGIONAL BUREAU encoder1 </Enc_Name>
    <Adr>
      <DevAdr> 10.184.8.1 </DevAdr>
    </Adr>
    <Stream uri="nxtp://234.0.0.1:5000/">
      <MulticastAdr> 234.0.0.1 </MulticastAdr>
      <MulticastPortNo> 5000 </MulticastPortNo>
      <EncodeForm> MPEG2 </EncodeForm>
      <EncodeRate> 6Mbps </EncodeRate>
    </Stream>
    <Stream uri="nxtp://234.0.99.1:5099/">
      <MulticastAdr> 234.0.99.1 </MulticastAdr>
      <MulticastPortNo> 5099 </MulticastPortNo>
      <EncodeForm> MPEG4 </EncodeForm>
      <EncodeRate> 384kbps </EncodeRate>
    </Stream>
    <Video>
      <VideoId> 59200 </VideoId>
    </Video>
  </Encoder>
</EncoderInf>

Figure 7. IP Encoder XML Instance Example

Outcome of Review

A review has been conducted by MLIT on technologies of XML, SOAP (Simple Object Access Protocol), and HTTP (Hyper Text Transfer Protocol) incorporated in a standard interface within its jurisdictions in order to allow metadata control servers and relevant systems to operate in a synchronized fashion.

The outcomes of the review are as follows:

1) Scattered placement of metadata control servers has alleviated the excess load on each server, thus image data distribution in real time has been realized
2) Regarding risk management, as in a case of disasters or catastrophe, a system in an office can operate in isolation, even if networking is disrupted due to a failure
3) Development of the interface standard allows various vendors to use a metadata control server with XML on SOAP/HTTP AP/HTTP
4) The visual image database created through synchronizations and coordination among various systems allows images to be displayed on screens of various systems, thus effectiveness and convenience in system operations is enhanced
5) A visual image data sharing system, allowing operators to understand the detailed status, enables them to take quick actions appropriately in the daily control and management of roads and rivers
Challenge

To respond to such critical needs of municipal offices or related organizations for image information owned by MLIT, further strenuous study effort, including institutional issues, is still required. The distribution of visual image information by Internet or 3G mobile phone (IMT2000) of various Internet providers or carriers poses barriers. These include the existing facilities, security or marketing strategies of each business entity. That is, compliance to stipulations or regulations in streaming distribution service or conformity to the server conditions of carriers will force some conversions to the specified transmission speed, the addresses, or the streaming method from the original ones. A primary issue is privacy.

Conclusion

The review discussed in this paper has been conducted on sharing technologies as Internet or optic fiber cable in order to apply targeted, effective, and efficient visual image data among operators or administrators of road and river control and management. The sphere of the review has included both designing technology as well as operational approaches, giving due consideration to responsible ranges of the related entities. Before the system is realized so that it is available ‘whenever’, to ‘whoever’, for ‘whatever images from whichever cameras across the nation’, various barriers have to be overcome toward the future. The current state-of-the-art technology is moving ahead day by day. The review to verify system operations at this time on large scale networks run by MLIT has been unprecedented. The outcome of the review was standard platform technologies for visual image data sharing systems within MLIT jurisdictions, which has already yielded effectiveness in operational synchronization with distributed servers and enhanced convenience in use. In view of that, the further effort to secure wide conformity to the standards in order to incorporate ever-progressing image data transferring technology is strongly required for future system enhancements.

Reference: