Information Transmission System
for
Earthquake Early Warning

September 3, 2007
Real-time Earthquake Information Consortium
Yoshinori Rokugo
Earthquake Early Warning System (Up Stream)

1) Number of Seismometer Distribution:
   - NIED: 800 points,
   - JMA: 200 points.

2) The information concentrated to JMA by using IP-VPN or FR (Back-uped by ISDN).

3) Contents of the information:
   - Real-time data of the earthquake,
   - Hypocenter information;
     including Latitude, Longitude, Depth and Magnitude.

4) Real-time data processing is performed at JMA to calculate Hypocenter parameter from P-waves data.
Earthquake Early Warning System (Down Stream)

EEW is distributed from JMA through WBSC (Weather Business Support Center) to the user by using leased line or IP-VPN.

The first users are able to redistribute EEW to the end uses by using several Transmission methods,
- Leased line,
- IP-VPN,
- The internet,
- IP V6 multicast,
- Satellite communication (CS) system,
- Mobile broadcasting Services.
End user estimates the seismic intensity (JMA) and the arrival time of S-wave by using Attenuation Relationship and Travel-Time Table.
新潟県中越沖地震(2007,07,16)

推定震度：6.2

地震情報
震源時：2007/07/16 11:04:52
震度：6.2
経度：138.60
緯度：37.79
深さ：16.0
震央距離：52.0
表示位置：震源

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Digital Hierarchy

North American (PDH)
- 64kbps \times 24 \rightarrow 1.5Mbps \times 4 \rightarrow 6Mbps \times 7 \rightarrow 45Mbps \times 6 \rightarrow 274Mbps

European (PDH)
- 64kbps \times 30 \rightarrow 2Mbps \times 4 \rightarrow 8Mbps \times 4 \rightarrow 34Mbps \times 4 \rightarrow 139Mbps

Japanese (PDH)
- 64kbps \times 24 \rightarrow 1.5Mbps \times 4 \rightarrow 6Mbps \times 5 \rightarrow 32Mbps \times 3 \rightarrow 100Mbps

SDH (1988)
- 6Mbps \times 3 \rightarrow 6Mbps \times 7 \rightarrow 51Mbps \times 4 \rightarrow 155Mbps \times n
The change of the Transmission Line

Metallic Line 400Mbps

Optical Line 1Gbps-20Gbps

Optical Line with DWDM 20Gbps x 120 waves
The Transmission Network Configuration

Backbone Network (Optical Mesh)

- Edge Node
  - Optical line
  - PON
  - FTTC (VDSL)
  - CATV
  - DSL

- Edge Node
  - Optical line
  - PON
  - FTTC (VDSL)
  - CATV
  - DSL

Access Line
Real-time Data Transmission over IPv4

Internet protocol architecture
Real-time Data Transmission over TCP/IP

Client-server model is used to transmit the real-time data. TCP connection (full duplex) is established, maintained, and terminated over IP datagram (connectionless).

**Sever**

- (SYN)
- SYN+ACK
- (ACK)
- DATA
- (ACK)
- (DATA)
- ACK
- FIN
- (FIN+ACK)
- ACK

**Client**

- SYN
- (SYN+ACK)
- ACK
- (DATA)
- ACK
- DATA
- (ACK)
- (FIN)
- FIN+ACK
- (ACK)

1s ~ 30s
Leased Line and IP-VPN

Digital Leased Line
High reliability STM (Synchronous Transfer Mode) is used.
- The transmission bandwidth is fixed depending on the digital hierarchy.
- Quality guarantee services are provided,
- the small delay is achieved,
- High cost.

IP-VPN
IP-VPN is originally constructed IP-based virtual private network closed in the telecommunications provider.
Well known protocol MPLS (Multi-Protocol Label Switching) is usually used for the routing (static routing with the L3 switch).
The bandwidth, and the average delay time etc, are ensured based on the (SLA: Service Level Agreement).
The main functions of the multicast are a data handling function, a group management and multicast security policy providing function.

Single IP packet is sent to multicast router in which the packet is copied of the required number to send to the down stream.
Main communication and broadcast satellites in Japan

Geosynchronous orbit

Above the equator

About 36,000km

(JCSAT-3)
(JCSAT-2A)
(JCSAT-1B)
(N-STAR a)
(Superbird-C)
(Horizons-1)

N-SAT-110
(Superbird-D)
(JCSAT-110)

BSAT-1a
1b
2a
2c
BS-3N

JCSAT-4A
JCSAT-3
N-STAR b

Superbird-A

BSAT-1a
1b
2a
2c
BS-3N

JCSAT-4A
JCSAT-3
N-STAR b

Superbird-C

MTSAT-1R (himawari No.6)

Communication Satellite: Communication using space satellite
Communication Satellite

Merits
- Coverage: The whole Japan and foreign countries,
- To broadcast simultaneously throughout the country,
- To provide redundant configuration (Duplicated the center),
- High security is provided,
- Bandwidth flexibly is provided from Several kbps to Several 10Mbps.

Demerits
A fixed propagation delay of about 250 milliseconds is produced.
The line utilization rates of 99.98% or more by heavy rain
(The antenna of 60cm $\phi$ is used in Tokyo).
To set up the parabolic antenna at the proper position.
Mobile broadcasting Services

MBSAT

Satellites and Gap-Fillers/GF

S-Band: 2.6GHz

Ku Band

12~18GHz

Ku Band

Gap-Filler/Repeater

Non satellite signal receiving area

Satellite Ctrl. Center at Mito and Yamaguchi

Broadcasting Center at Oi-city

Car, Train, Boat, Out door, Home, etc.

Shaded area of buildings and Mountains, Tunnel, etc.

Home Wireless Transmission: ZigBee

Transmission speed: Maximum 250kbps
Transmission Distance: 30m or less

Data Rate (Mbps)

WPAN
WLAN
WMAN
WWAN

ZigBee 802.15.4
Bluetooth 802.15.1
IEEE 802.20
WiMax IEEE 802.16
IEEE 802.22
WiFi 802.11
802.15.3
802.15.3a
802.15.3c

From ZigBee Alliance

Transmission range:

0.01 0.1 1 10 100 1000

From ZigBee Alliance

Transmission speed: Maximum 250kbps
Transmission Distance: 30m or less

Data Rate (Mbps)

WPAN
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From ZigBee Alliance
· Interconnection among the sensors and the controllers.
· Topologically 64k terminals.
· Zigbee is used among the wireless LANs utilized the 2.4GHz band in Japan.
### Summary of the Data Transmission

<table>
<thead>
<tr>
<th></th>
<th>Leased Line</th>
<th>The internet (TCP)</th>
<th>IPv6 multicast</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission delay</td>
<td>Smallest</td>
<td>Large (fluctuate)</td>
<td>Small</td>
<td>Large (stationary)</td>
</tr>
<tr>
<td>multicast</td>
<td>none</td>
<td>none</td>
<td>practicable</td>
<td>practicable</td>
</tr>
<tr>
<td>reliability</td>
<td>High</td>
<td>Low</td>
<td>Relatively safe</td>
<td>High</td>
</tr>
<tr>
<td>Cost</td>
<td>High</td>
<td>Lowest</td>
<td>Low</td>
<td>Highest</td>
</tr>
</tbody>
</table>
Public Announcement

Media: Television, radio, and disaster prevention wireless.
Broadcast area: limited.
Content: Certain information is only once sent for the each EEW.
EEW sending criteria: Seismic intensity; 5- or more, Detection points; 2 or more.

Television