Web-based Network and Systems Management

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Today’s Networks

World-Wide Web
Email, DNS, FTP
News, Telnet, IRC
RealAudio, RealVideo
MBone

Fast Ethernet
Token Ring
Gigabit Ethernet
Ethernet
FDDI

ATM
SDH
Access Networks
B-ISDN

IN/AIN
SS#7
PSDN
PCS

PSTN

Local, Long-distance,
Oversea Phone service
080, 070, collect-call
third-party IN service
cellular, C2, PCS, TRS

Computer Networks
Video Conferencing
Electronic Commerce
Internet Phone
Banking, Accounting
Distance Learning

Telecom Networks
Video-on-Demand
Tele-conferencing
Video-conferencing
Internet Telephony
Standard Management Frameworks

- Internet Network Management Framework (IETF)
  - SNMPv1 (Internet Full Standard)
  - SNMPv2, SNMPv3

- OSI Network Management Framework (ISO/ITU-T)
  - CMIP, X.700 Series

- Telecommunications Management Network (ITU-T)
  - M.3000 Series

- DMI Management Framework (DMTF)
  - DMI 1.x, DMI 2.0
  - WBEM
Traditional Management Systems

Many Proprietary Frameworks

No Common Foundation, No Consistent View
Web-based Management

*Foundation for a Solution*

- Open, ubiquitous, cross platform, scalable
- Low entry cost
- Ideal for Integration of multiple domains
- Preserve existing investments
What is Web-based Mgmt?

- Uses the World-Wide Web (Web) technology for the management of networks, systems and applications

- the use of **Web server and browser technology** for monitoring, trouble shooting and reporting network and systems and application management information

- May incorporate new Internet technologies such as Java, CORBA, Active X, CGI, DCOM, etc.
Simple Web-based Mgmt (1)

Internet Web Browser

HTTP

Web Server

Mgmt Info

Independent Mgmt Program

Devices or applications

Agent
Simple Web-based Mgmt (2)
Simple Web-based Mgmt (3)

- Requires embedded Web server and agent in each managed device!
Filling in the Blanks

Web-based Technology

HTTP, HTML

SNMP, CMIP, TMN, DMI, etc

What’s Missing:

- Inclusion of existing standards (SNMP, CMIP, TMN, DMI, etc.)
Advanced Web-Based Mgmt

Internet Browser

Management Services

SNMP  CMIP  DMI  Other

Devices or Applications

HTTP-Based Access

HTTP-Based Access
Key Web Technologies

- HyperText Markup Language (HTML)
- Web-based Management User Interface (WebMUI)
- Web Server
- HyperText Transfer Protocol (HTTP)
- Common Gateway Interface (CGI)
- Java
- CORBA
- Web Resource Access Methods
HyperText Markup Language (HTML)

- The basic textual content of Web resource
- Static HTML vs. Dynamic HTML
  - Static HTML
    - documents are stored at server’s storage
  - Dynamic HTML
    - created instantly and contains information which is the result of some query that the client has sent
- HTML interaction
  - hyperlinks (clickable buttons), send request, and response
- Platform independent
Web-based Management User Interface (WebMUI)

- Provides a Web browser user interface for mgmt
  - inexpensive & easy-to-use alternative to traditional UI (such as Windows, command line interface)
- Provides static, dynamic and interactive content of management information of systems and networks
- Can be used to configure, monitor and control managed systems via Web browser
- Can upload firmware updates and configuration files
- Reduces support and documentation cost
- No need for experts to manage the system
- Adds value to products!
Web Server?

- World-Wide Web Server
- Also known as HTTP Server or HTTP Daemon
- Designed to communicate with Web clients (browsers such as Netscape Navigator, MS Internet Explorer) using HTTP protocol
- The repository of Web documents whose types are HTML and any application data with MIME type
- Web documents are static or generated dynamically
- Typically runs on general purpose computers (e.g., NT server, Unix & Linux workstations)
HyperText Transfer Protocol (HTTP)

- The primary transfer protocol used by WWW
- simple client-server based application protocol built upon TCP
- typical transaction
  1. client establishes a connection to the server
  2. client issues a request for information and waits
  3. server processes the request
  4. server sends a response
  5. client closes the connection
HyperText Transfer Protocol (2)

- HTTP operations: GET and POST
  - GET operation
    - used to retrieve information from the server
    - the response will contain the information requested by the client (if successful)
  - POST operation
    - used to send information to the server
    - when the server receives a POST operation, it passes the data included in it to the executable resources (CGI script or Java object)
HyperText Transfer Protocol (3)

✦ HTTP 1.0 vs. HTTP 1.1

HTTP 1.0
- non-persistent connection
- for each text or image in a document, a separate connection is needed

HTTP 1.1
- persistent connection
- only a single connection is needed for multiple text and images in a document
Common Gateway Interface (CGI)

- CGI is a protocol defined for executable resources to interface with information server, such as HTTP server.
Java

- Java is common client-side executable code supported by most Web browsers

![Diagram of Java bytecode execution process]

- Request Java applet
- Verify Bytecode
- Interprete bytecode
- Execute
- Verify memory allocation
- Download (using HTTP)
possibilities for communication with the server through the use of sockets
- API exists that enable the use of UDP, TCP

also provides an API for remote invocation of Java methods => RMI API
- RMI API is basis for JMX of Sun Microsystems
- allows developers of distributed applications to use remote methods (procedure calls) between entities residing in different address spaces
CORBA

- Distributed object-oriented technology
- OMG’s solution for providing *interoperability* among the rapidly proliferating number of hardware and software products
- Object Management Architecture (OMA)
- CORBA Architecture
- Interface Definition Language (IDL)
- Implementation languages: C++, Java, Smalltalk, etc.
Object Management Architecture

Object Request Broker

Common Facilities
- Vertical Common Facilities
- Horizontal Common Facilities

Common Object Services
- Naming
- Persistence
- Life Cycle
- Properties
- Concurrency
- Collections
- Security
- Trader
- Externalization
- Events
- Transactions
- Query
- Relationships
- Time
- Change Management
- Licensing

Application Objects

User Interface
Information Management
System Management
Task Management

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CORBA Architecture
Web Resource Access Methods
(Using Web-Server)

Client (Browser)

Static HTML
HTTP

Static Information

Web-Server
Web Resource Access Methods

(Using CGI)

Client (Browser)

Web-Server

CGI Request/Response (HTML files created dynamically)

CGI Script

Resource (DB)
Web Resource Access Methods
(Using Java Applets)

Client (Browser)

Java Applet

Web-Server

Servlet

Java Applet Codes

Web-Server API

Servlet

JDBC

Resource (DB)

CORBA/Java
Server Objects

HTTP

HTTP

sockets/RMI

CORBA/RMI

Servlet

API

HTTP
Push & Pull Technology

- The limitations of HTTP & HTML
  - Dynamic update of continuous data is difficult and inefficient
  - Notification-type communication is not supported
- Push & Pull technology is used for dynamic data from a server
  - Manual refresh button on page
  - HTML Client-pull
  - Server push
  - Java applet/servlet
used to **automatically** refresh or replace document by another after a certain time-interval has passed

achieved by HTML META tag and useful for automatic updates (i.e., monitoring)

for example:

```html
<HTML>
<HEAD>
<META HTTP-EQUIV="Refresh" CONTENT=10>
<TITLE>Example document</TITLE></HEAD>
<BODY>Here’s some text</BODY>
</HTML>
```

reload this page after 10 seconds has elapsed.

```html
<META HTTP-EQUIV="Refresh" CONTENT="10; URL=http://server/page.html”>
```

replace this document by another called “page.html” after 10 seconds.
Client-Pull Interactions

HTTP Client

Request

Connection #1

x

Request

Connection #2

HTTP Server

Response #1: HTML document refresh after x seconds

Response #2: new or updated HTML document
Server push

- Possible through the use of CGI
- When a client makes a request to the CGI script, the script returns documents, but the HTTP connection between server and client stays open till the last document is returned.
- It is very useful technique for when the client is to be notified of certain real-time events (e.g., event reports).
- A problem with this is that a separate HTTP connection is kept open to each client for an indefinite time.
Server Push Interactions

HTTP Client

Request

Connection

HTTP Server

Document #1

Document #2

Document #3

...

Document #N
Java Applet/Servlet

- HTTP & HTML only is client driven
- These limitations can be overcome by using Java and/or CORBA
- Download Java applets from Web server to Web browser
- Java applets are executed on Web clients and communicates with servlet
Java Applet/Servlet Interaction

HTTP Client

Request

Connection #1

Java Servlet

HTTP Server

Java Applet

Connection #2
Example of Applet/Servlet Push (1)

- Data Collection & Monitoring

![Diagram showing the data collection and monitoring process with pushover HTTP]

Subscription
Management data push over HTTP
Example of Applet/Servlet Push (2)

- Notification

```
Management station

Event notification applet  ♦️ Rule edition applet  ♦️ Notification subscription applet
push

Event manager servlet  ♦️ Notification collector servlet  ♦️ Notification dispatcher servlet
push  push

Management server  ♦️ Agent

Subscription
Management data push over HTTP
```
Embedded Web Server Technology

- Embedded Web Server (EWS)
- WebMUI Examples
- Example Products
- Challenges in EWS for Web-based Management
Embedded Web Server (EWS)

- A Web server which runs on embedded systems with limited computer resources
  - real-time OS, little memory, low CPU, no disks, etc.
- Provides a Web browser interface between Web client and embedded system applications
- Example application areas
  - Present: data and telecom network devices
  - Near future:
    - office equipment (such as copiers, fax, printers, scanners)
    - consumer electronics (such as VCR, TV, refrigerator, stove, washer, microwave oven, rice cooker, etc.)
    - test and measurement equipment
    - machine and process control equipment
    - medical instrumentation
WebMUI through Embedded Web Server (EWS-WebMUI)

- Web browser + EWS + Web documents + Management applications
- Web browser as a user interface
- EWS as a management information server
- Web documents as management information
- Management applications interact with real-time OS or embedded applications to provide management information or to control the system
EWS-WebMUI Architecture

Embeded System

EWS

Configuration

Security

Application Interface

HTTP Engine

Management Application

(Configuration, Monitor and Control)

Embedded Application

RTOS

Web documents (html)

Web Browser

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Advantages of WebMUI

- Provides enhanced user interface
  - Ubiquitous management
  - User-friendly interface via standard Web browsers
- Low development cost
  - No porting & distribution efforts for user applications
  - Platform independent graphical user interface
  - Short development time (short time-to-market)
- Easy maintainability
  - Web documents and associated programs can be easily modified
## Comparison of Mgmt User Interfaces

<table>
<thead>
<tr>
<th>Feature</th>
<th>CLI</th>
<th>Windows</th>
<th>WebMUI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-platform</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Remote Access</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>User Friendly</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Develop. Cost</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Maintainability</td>
<td>Easy</td>
<td>Hard</td>
<td>Medium</td>
</tr>
</tbody>
</table>

CLI : Command Line Interface
Examples of EWS-WebMUI

- Alteon ACEdirector 3
  - Layer 4 switch (http://www.alteon.com)

- Cisco 2924
  - 24 port 10/100 Mbps Ethernet Switch

- Bay Networks
  - Internet Router
Alteon ACEdirector 3 WebMUI

### Switch Ports Dashboard

<table>
<thead>
<tr>
<th>Status</th>
<th>Switch Port Info</th>
<th>Operational Status</th>
<th>Speed Duplex Flow Control</th>
<th>Input Frames Output Frames</th>
<th>Link Status Changes Total Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port 1</td>
<td>vip: FORWARDING rmon: disabled tagging: disabled PVID: 1</td>
<td>operational</td>
<td>100/Full/Both</td>
<td>264356460 202276634</td>
<td>1 0</td>
</tr>
<tr>
<td>Port 2</td>
<td>vip: FORWARDING rmon: disabled tagging: disabled PVID: 1</td>
<td>operational</td>
<td>100/Full/Both</td>
<td>166645076 297932756</td>
<td>1 0</td>
</tr>
<tr>
<td>Port 3</td>
<td>vip: FORWARDING rmon: disabled tagging: disabled PVID: 1</td>
<td>operational</td>
<td>100/Full/Both</td>
<td>579113637 524894018</td>
<td>3 0</td>
</tr>
<tr>
<td>Port 4</td>
<td>vip: FORWARDING rmon: disabled tagging: disabled PVID: 1</td>
<td>operational</td>
<td>100/Full/Both</td>
<td>39591193 37287010</td>
<td>5 4</td>
</tr>
<tr>
<td>Port 5</td>
<td>vip: FORWARDING rmon: disabled tagging: disabled PVID: 1</td>
<td>operational</td>
<td>100/Full/Both</td>
<td>102223590 99951929</td>
<td>5 4</td>
</tr>
<tr>
<td>Port 6</td>
<td>vip: FORWARDING rmon: disabled tagging: disabled PVID: 1</td>
<td>operational</td>
<td>100/Full/Both</td>
<td>363000442 33993173</td>
<td>7 2</td>
</tr>
<tr>
<td>Port 7</td>
<td>vip: DISABLED rmon: disabled tagging: disabled PVID: 1</td>
<td>operational</td>
<td>100/Full/Both</td>
<td>52071 58373589</td>
<td>6 1</td>
</tr>
<tr>
<td>Port 8</td>
<td>vip: DISABLED rmon: disabled tagging: disabled PVID: 1</td>
<td>operational</td>
<td>Any/Both/Both</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>Port 9</td>
<td>vip: DISABLED rmon: disabled tagging: disabled PVID: 1</td>
<td>operational</td>
<td>1000/Full/Both</td>
<td>0 0</td>
<td>0 0</td>
</tr>
</tbody>
</table>
Cisco 2924 WebMUI

Cisco Visual Switch Manager Home

Switch IP Address: 141.223.82.19
Name of switch: Cisco 2924
Physical location: DP&NM Lab, PIRL 454, POSTECH
User/Contact Name: Myung-Sup Kim
Assign/Change password: 
Reconfirm password: 

Link Up  No Link Status  Link Faulty or Port Disabled
Bay Networks WebMUI
Requirements for EWS

- Low resource requirements
  - must use as little RAM, ROM and CPU as possible

- High functionality
  - provide all the functionality that CLI provides & more

- High reliability
  - highly reliable like one of the embedded system components

- Powerful application interface
  - mechanisms for the Web server to interact with embedded applications

- High portability
  - portable on various RTOS and embedded systems

- Security
  - as a means to limit access to sensitive information or configure & control
Protocol Considerations

- Explicit cache control
  - For static Web page, caching is desirable, eliminating requests for redundant information
  - Dynamically-generated Web documents must not be cached in order to retrieve up-to-date information
  - HTTP 1.1 allows server to control the Web cache

- Persistent TCP connection
  - TCP implementations maintain connection state information for two minutes after connection closed
  - HTTP 1.1 allows for a single persistent TCP connection between the browser and server
Application Interface - CGI

1. Request URL
2. Function Call
3. Parse argument
4. Generate HTML
5. Return HTML
6. Send HTML

Web Server

Application Program

- URL is mapped to function call
- HTML is generated in application program
- Easiest for Web server developer
- Most difficult for Web page designer
- Web documents are difficult to maintain
Application Interface - SSI

- Server Side Include (SSI)
- Achieved via Server Side Scripts
- Web pages may be developed using authoring tools
- Insert markup tags into Web documents
- Runtime HTML parsing for inserting dynamic information
- Easier to use than CGI
- Microsoft calls this Active Server Page (ASP)
Application Interface - Preprocessed SSI

1. Request URL
2. Function Call
3. Execute Function
4. Execute Function
5. Return Value
6. Replace with return value
7. Send HTML

Web Server

Application Program

- Web page into source program
- Web pages may be developed using authoring tools
- Insert markup tags into Web documents
- Pre-runtime HTML parsing
- Off-loads Web server processing
EWS-WebMUI Design Techniques

- **Virtual Web Server**
  - HTML pages with graphics from elsewhere on the network with only the dynamic data from the server

- **Cascade Style Sheet (CSS)**
  - By attaching style sheets to structured documents, CSS prevent retransmission of HTML design information

- **Portable Network Graphic**
  - The transmission of smaller images may be improved by using Portable Network Graphics (PNG)

- **Encoding with compression**
  - An encoding format produced by the file compression program such as gzip and deflate
Extending the Architecture

- The limitations of HTTP & HTML only
  - Dynamic update of continuous data is difficult and inefficient
  - Notification-type communication is not supported
  - Transmission of user commands is very tedious
- These limitations can be overcome by using Java and/or CORBA
- Download Java applets from Web server to client
- Java applets are executed on Web clients and communicates with embedded applications
Extended Architecture

Embedded System

Web documents (html, Java applets)

RTOS

Embedded Application

Management Application (Configure, Monitor and Control)

Configuration

Security

Application Interface

EWS

HTTP Engine

Comm. Server

Java applet

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Example of Extended Architecture

- Web documents (html, Java applets)
- Embedded System
  - EWS
    - Configuration
    - Security
    - Application Interface
  - HTTP Engine
- Management Application (Configure, Monitor and Control)
- RTOS
- Embedded Application
- Web Browser
  - Java SNMP Manager
  - SNMP Agent

Product - Agranat EmWeb

- Embed C code inside HTML documents
- Lets you provide dynamic content under application
- Unique HTML-to-C preprocessor
- Executable Image size - typically 25K bytes
Product - Allegro RomPager

- Email notifications
- Email reading
- Executable size - less than 60Kbyte
Summary on EWS

- Web-based user interface is no longer limited to computer applications - ideal for managing any network devices using Embedded Web Server
- WebMUI provides ubiquitous, simple but powerful, user-friendly management user interface
- This “webtification” of network devices has generated a new philosophy for network element management
- SNMP will continue to play an important role because of needs for enterprise network mgmt
- SNMP can be easily integrated with EWS
Challenges in EWS for WebMUI

- How to make it as **small** as possible?
- How to make it **system independent**?
  - Portable on various real-time OS (such as VxWorks, pSOS, Virtex)
- How to make it so that it puts the **least amount** of resource and performance **overhead** to the system?
- Which **application interface functions** do we put in?
EWS Commercial Products

- Agranat
- SpyGlass
- Web Device Inc.
- Quiotix
- Accelerated Technology Inc
- Embedded System Product Inc.
- Integrated Systems Inc.
- Lynx Real Time Systems
- Microtec
- Microware Systems Corp.
- Pacific Softworks
- Phar Lap Software Inc.
- QNX Software Systems Ltd
- RTMX Inc
- Wind River Systems

- WebEm
- MicroServer
- Picoserver
- QEWS
- Nucleus
- RTXCnet
- pSOS
- LynxOS
- Spectra
- Internet OS-9
- Fusion
- Real-time ETS kernel
- QNX Internet Toolkit
- er-html
- Tornado development environment
Industrial Web-based Management Effort

- Web-Based Enterprise Management (WBEM)
- Java Management Extensions (JMX)
What’s the WBEM

- Web-Based Enterprise Management is a set of management and Internet standard technologies developed to unify the management of enterprise computing environments.
**WBEM History**

- June 1996: Microsoft leads team of 70 vendors forming WBEM
- April 1997: Common Information Model 1.0 specification completed, which was based on HyperMedia Management Schema (HMMS)
- HyperMedia Object Manager (HMOM) and a HTTP-based protocol called HyperMedia Management Protocol (HMMP) was rejected by the Internet Engineering Task Force (IETF)
- March 1998: CIM 2.0 finished
The WBEM Triangle

Data Description

CIM

Transport Encoding

HTTP

Access

</xmlCIM>
The Common Information Model (CIM) defines the Schemas used to represent the real-world objects being managed. CIM uses an object-oriented paradigm, where manageable objects are modeled using the concepts of classes and instances.

- CIM Specification V2.2
- CIM Schema V2.2 (8 MOF)
  - CIM_Schema22
    - CIM_Core22
    - CIM_Application22
    - CIM_System22
    - CIM_Device22
    - CIM_Philysical22
    - CIM_Network22
    - CIM_DAP22
CIM to XML Mapping

◆ eXtensible Markup Language
  ◆ A simplified subset of SGML (not an Application)
  ◆ Powerful and flexible
  ◆ Applications (optionally) define their own DTDs; no fixed tag sets
  ◆ Primary purpose is to express structure and semantics of data

◆ XML has been leveraged to define
  ◆ Declarations of CIM objects that can be easily transformed into infinitely many representations
  ◆ CIM Messages for encapsulation over HTTP
Basic HTTP Operations

- Work on existing web servers
- Not mandate any new HTTP extensions
- Intuitively obvious to typical Web programmers
- Compatible with existing Web programming
- Simple in concept and implementation

- CIM Operations form the HTTP payload, using XML
- encapsulation of these messages in HTTP request and response messages
What is JMX

- Java Management Extension (JMX), formerly Java Management API (JMAPI), is a universal, open extension of the Java programming language for management.
- JMX provides the tools for building distributed, Web-based, modular and dynamic solutions for managing devices, applications and service-driven networks.
- Utilizing the JMX, developers are able to create Java technology-based code that are universally and dynamically managed, quickly and with little effort.
- The specification for JMX has been developed by Sun Microsystems, Inc. along with management industry companies.
JMX Architecture

Manager Level
- Proprietary Management Application
- Web Browser
- Proprietary Management Application

Agent Level
- Protocol Adaptors
- MBean server
- Service

Instrumentation Level
- MBean (Manageable Bean registered in the server)
- Plain JavaBeans component (not registered)

Additional Management Protocol APIs
- SNMP Manager API
- CIM/WBEM Manager API
- TMN Manager API
JMX Specification

- JMX Instrumentation and Agent specification is currently in public release status

- Awaiting completion of the associated Reference Implementation (RI) and Compatibility Test Suite (CTS).

- May be changed or updated by the Expert Group as a result of experience gained during the writing of the RI and/or the CTS
R & D Efforts

- Integrated Web-based management architecture
- Internet/Intranet Network Traffic Monitoring, Analysis and Reporting using MRTG+
- WebTrafMon: Internet Traffic Type and Source-Destination Monitoring and Analysis System
- Web-based Internet/Intranet Application Service Management: Mail Server Management
- TMN-based Integrated Network Management using Web Technology
- Embedded Web Server for Managing Internet Devices
Integrated WBM Architecture

- Web Browser (Management Applications)
  - Java applets

- SNMP-based devices or apps
- CMIP-based devices or apps
- DMI-based devices or apps
- Proprietary devices or apps

- SNMP
- CMIP
- DMI

- Other Gateways

- HTTP/HMMP
- CORBA/RMI/etc.

- Web Server
  - Management Services
    - Config
    - Perform
    - Fault
    - Security
    - Account

- Existing Mgmt Systems
Internet/Intranet Network Traffic Monitoring, Analysis and Reporting using MRTG+

- What is MRTG+?
  - Network traffic monitoring, analysis & reporting system
  - Extended Multi-Router Traffic Grapher (MRTG)
    - added **security, threshold reporting & sensitive map**
  - uses Web browser, Web server & SNMP agents
  - generates HTML pages containing GIF images which provide a LIVE visual representation traffic
  - based on Perl and C
  - being used to monitor POSTECH, POSCO, DACOM enterprise networks
MRTG+ System Requirements

- most UNIX platforms and Windows NT
- Web Server
- GD library
  - used for generating graphs in GIF images
- Perl version 5.003 or later
- Web browser
  - Netscape Navigator, MS Internet Explorer
MRTG+ Architecture (1)
MRTG+ Architecture (2)

- Manager system
  - configurator, collector, analyzer, grapher, reporter
- Managed devices
  - enterprise network devices (router, hub, switch)
- Management Information Repository
  - local file system
- Web server and browser
  - security
  - uses client-pull META tag
MRTG+ Implementation Architecture
Network Monitoring Map (1)
Network Monitoring Map (3)
Network Interface Index Page

- 169.140.1.1 (r7513_bonsa)
  - 1: Fddi0/0 (169.140.1.29)
  - 2: Ethernet2/0 (169.140.2.33)
  - 3: Ethernet2/0 (169.140.2.55)
  - 4: Ethernet2/0 (169.140.2.97)
  - 5: Ethernet2/0 (169.140.2.129)
  - 6: Ethernet2/0 (169.140.2.161)
  - 7: Ethernet2/0 (169.140.2.193)
  - 8: Ethernet2/4 (169.140.3.1)
  - 9: Ethernet3/1 (169.140.3.1)
  - 10: Ethernet3/2 (169.140.3.1)
  - 11: Fddi0/0 (169.140.3.65)
  - 12: Ethernet3/4 (169.140.3.97)
  - 13: Ethernet4/1 (169.140.3.129)
  - 14: Ethernet4/2 (169.140.3.161)
  - 15: Serial0/3 (headquarter -> posco_house) ()
  - 16: Serial0/4 (headquarter -> list3 bd. TI) ()
  - 17: Ethernet4/3 (169.140.4.1)
  - 18: Serial0/5 (bonsa -> kwangyang fddi 768kbps) (169.140.11.193)
  - 19: Ethernet5/0 (169.140.11.225)
  - 20: Fddi0/0 (169.140.9.193)
  - 21: Serial0/0 (headquarter -> posdata hundang center 364k) ()
  - 22: Serial0/1 (headquarter -> posdata hanjin 3P) (169.140.12.97)
  - 23: Serial0/2 (headquarter posco -> posco_train-house joondokwan TI) (169.140.27.148)
  - 24: Serial0/2 (headquarter -> posco_house) (169.140.1.65)
  - 25: Serial0/4 (headquarter -> list3 bd. TI) (169.140.1.225)
  - 26: Serial1/6 (posco -> POSREC hd.) (169.140.2.1)
  - 27: Serial0/5 (bonsa -> kwangyang fddi 768kbps) (169.140.12.97)
  - 28: Serial1/6 (bonsa -> kwangyang fddi 768kbps) (169.140.12.97)
  - 29: Ethernet4/5 (169.140.1.161)
  - 30: Serial1/1 (headquarter -> energy center 2P) (169.140.4.33)
  - 31: Serial1/2 (headquarter -> posdata hanjin 2P) (169.140.4.129)
  - 32: Serial1/3 (headquarter -> duk sung kwan 2P) (169.140.1.193)
  - 33: Serial1/4 (headquarter -> POSCO center for fitting) (169.140.4.161)
  - 34: Serial1/5 (headquarter -> center for visitors of posco) (169.140.4.92)
  - 35: Serial1/6 (posco -> POSREC hd.) (169.140.4.65)
  - 36: Serial1/7 (headquarter -> BS TI active) (169.140.1.129)

- 169.140.1.2 (c7000_c)
Traffic Monitoring Graph Output

Traffic Analysis for Serial11/7
headquarter -> IBS T1 active

System: r7513_bonsa in
Maintainer:
Interface: Serial11/7 (36)
IP: No hostname defined for IP address (169.140.1.129)
Max Speed: 193.0 kBytes/s (propPointToPointSerial)

The statistics were last updated Friday, 26 September 1997 at 20:32, at which time 'r7513_bonsa' had been up for 72 days, 8:17:44.

'Daily' Graph (10 Minute Average)

'Weekly' Graph (30 Minute Average)
Active Subnet & Error Reporting

Most Active Subnets

<table>
<thead>
<tr>
<th>In Max %</th>
<th>Out Max %</th>
<th>In Avg %</th>
<th>Out Avg %</th>
<th>In Current %</th>
<th>Out Current %</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>92.2</td>
<td>24.5</td>
<td>4.0</td>
<td>5.7</td>
<td>0.2</td>
<td>5.1</td>
<td>169.140.1.24</td>
</tr>
<tr>
<td>52.6</td>
<td>45.5</td>
<td>16.7</td>
<td>7.5</td>
<td>14.1</td>
<td>2.7</td>
<td>169.140.1.36</td>
</tr>
<tr>
<td>17.6</td>
<td>77.5</td>
<td>4.4</td>
<td>14.2</td>
<td>1.7</td>
<td>4.7</td>
<td>169.140.1.27</td>
</tr>
<tr>
<td>46.2</td>
<td>11.3</td>
<td>2.0</td>
<td>2.4</td>
<td>0.2</td>
<td>1.4</td>
<td>169.140.1.25</td>
</tr>
<tr>
<td>34.1</td>
<td>21.0</td>
<td>1.2</td>
<td>4.0</td>
<td>0.2</td>
<td>1.6</td>
<td>169.140.1.31</td>
</tr>
<tr>
<td>3.4</td>
<td>19.3</td>
<td>0.4</td>
<td>2.8</td>
<td>0.2</td>
<td>1.9</td>
<td>169.140.1.23</td>
</tr>
<tr>
<td>18.8</td>
<td>3.7</td>
<td>4.7</td>
<td>0.6</td>
<td>4.2</td>
<td>0.4</td>
<td>169.140.1.21</td>
</tr>
<tr>
<td>17.7</td>
<td>1.9</td>
<td>1.0</td>
<td>0.4</td>
<td>0.1</td>
<td>0.2</td>
<td>169.140.1.31</td>
</tr>
<tr>
<td>1.6</td>
<td>16.8</td>
<td>0.4</td>
<td>0.9</td>
<td>0.2</td>
<td>0.1</td>
<td>169.140.1.31</td>
</tr>
<tr>
<td>17.6</td>
<td>0.6</td>
<td>0.9</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
<td>169.140.1.41</td>
</tr>
<tr>
<td>0.6</td>
<td>17.5</td>
<td>0.1</td>
<td>0.8</td>
<td>0.0</td>
<td>0.1</td>
<td>169.140.1.41</td>
</tr>
<tr>
<td>10.5</td>
<td>5.5</td>
<td>1.4</td>
<td>2.9</td>
<td>1.4</td>
<td>2.7</td>
<td>169.140.1.30</td>
</tr>
</tbody>
</table>

Most Error-Rate Subnets

<table>
<thead>
<tr>
<th>In Max %</th>
<th>Out Max %</th>
<th>In Avg %</th>
<th>Out Avg %</th>
<th>In Current %</th>
<th>Out Current %</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7</td>
<td>0.0</td>
<td>2.6</td>
<td>0.0</td>
<td>2.6</td>
<td>0.0</td>
<td>err.169.140.1.23</td>
</tr>
</tbody>
</table>

포함 문자자역의 Network Segment들의 가장 활발하지 않은 부분에 대한 Online-Report를 합니다.
환경적에 따라 현재시점 기준하여 traffic의 현재치 또는 평균치가 15% 이상인 경우, 최대치가 40%인 경우는
빨간색으로 표시됩니다.
또한 일일 In/Out ratie의 합이 15% 을 넘어도 표시됩니다.

POSTECH DP&NM Lab
CPU Load Monitoring

CPU Load

The statistics were last updated Friday, 6 March 1998 at 11:30

Daily' Graph (5 Minute Average)

Max %: 47.0 % (47.0%)  Average %: 10.0 % (10.0%)  Current %: 13.0 % (13.0%)

Weekly' Graph (30 Minute Average)

Max %: 60.0 % (60.0%)  Average %: 10.0 % (10.0%)  Current %: 12.0 % (12.0%)
MRTG+ Experiences (1)

- Deployed at POSCO & POSTECH
- POSCO (‘97.6 ~ present)
  - POSCO Headquarter & POSCO Steel Works (Pohang), Kwangyang Steel Works, POSCO Center (Seoul)
  - 20,000+ network nodes
  - 400+ network interfaces (FDDI, ATM, Ethernet, WANs)
  - 54MB disk space (100KB/interface)
- POSTECH (‘97.6 ~ present)
  - 2,000+ network nodes
  - 100+ network interfaces (Gigabit Ethernet, FDDI, Ethernet, Fast Ethernet, KORNET, DACOM, KREONET WANs)
MRTG+ Experiences (2)

- Enterprise network monitoring & reporting
  - traffic load monitoring (enterprise-wide & per link)
  - network/link fault monitoring
  - error rate detecting and reporting
  - used in network upgrade and planning
- POSCO network administrators “prefer this over IBM NetView & SunNet Manager”
  - simple to install, easy to learn, easy to operate
  - very economical compared to commercial NMS
- NM Traffic Overhead
  - SNMP traffic is less than 1% of total traffic
MRTG+ Summary

- Web-based enterprise network monitoring, analysis & reporting system
  - provides load stats, error, active subnet reporting
  - uses existing Web technology & SNMP agents
  - very easy to install, learn & operate
  - very cheap since it uses mostly freely available tools

- Deployed in many sites world-wide
  - POSCO, POSTECH, DACOM
  - http://wwwnet.princeton.edu/monitoring.html
MRTG++

- Auto configuration & Reconfiguration
  - Simplify configuration

  ![Diagram](image)

  - Minimal user intervention to manage
  - Easy user interface for configuration
  - Discovery specific types of devices to be monitored
  - Monitor and apply configuration changes automatically

- Directly configure each device
- Globally configure (configure simultaneously on multiple devices)
Automatic Network Map Generation

- Look for managed devices in the specified range of IP addresses
- Retrieve information
  - network connectivity
  - properties and functions
  - policy, network name and address related information
  - geometric and geographical information
- From the router information (BGP, OSPF) and SNMP MIB-II
- Generate network connectivity table and draw network map
Configuration Manager

- Add/Remove managed device
- Retrieve configuration status
- Apply configuration change
- Control monitoring job
MRTG++ Architecture
Network Map Generator Example
Configuration Manager Example
WebTrafMon

What is WebTrafMon 1.0?

- Web-based Internet/Intranet Network Traffic Type and Source/Destination Monitoring and Analysis System
- Classification of all possible protocol information
  - show information per protocol layer
- Security
- Historical traffic information analysis
- Real-time traffic information analysis
## Comparison with Existing Monitoring Tools

<table>
<thead>
<tr>
<th></th>
<th>MRTG</th>
<th>Etherfind</th>
<th>NFSwatch</th>
<th>TCPdump</th>
<th>Argus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Web-based?</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Analysis</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>capability?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Per Host</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Traffic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Information?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Per Protocol</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Traffic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Information?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>
WebTrafMon Design Architecture

Network

packet packet packet packet......

Packet capturer

Data filter

Data logger

Log file

Data reader

Analyzer

View controller

Web server

Data repository

Result

Web Browser

User Interaction
Probe

- Packet Capturer - captures packets from the network
- Data Filter - analyzes the captured packets
  - MAC layer
    - packet size
  - Network layer
    - IP (host information), IPX, ARP, RARP,….
  - Transport layer
    - TCP, UDP, ICMP,….
  - Application layer
    - Telnet, FTP, HTTP, SMTP, SNMP, ….
- Data Logger - stores analyzed data into log file
Viewer

- Data reader
  - reads the log file that the probe has generated

- Analyzer
  - analyzes user requests that the view controller has requested and provides the information as Web documents via Web server

- View controller
  - interacts with the user via Web browser to process user requests
WebTrafMon System Requirements

- Operating System
  - Linux (kernel 2.0.32)
  - Intel x86
- libpcap 0.4a6
- Perl 5.004_01
- Apache Web Server 1.2.5
Traffic Source Analysis

| Time    | 22:23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Day View| Now  | 21:00 |

**Monitoring Time:** Sun Nov 21 21:36:03 KST 1999

| Total size of data | 898,673 bytes | 2,083 packets | 153 hosts |

<table>
<thead>
<tr>
<th>Host Name</th>
<th>Data Sent (bytes)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>angels.postech.ac.kr</td>
<td>567.077 bytes</td>
<td>66.31%</td>
</tr>
<tr>
<td>mm.postech.ac.kr</td>
<td>77.033 bytes</td>
<td>9.95%</td>
</tr>
<tr>
<td>219.192.33.53</td>
<td>51.163 bytes</td>
<td>9.52%</td>
</tr>
<tr>
<td>hannae.posttech.ac.kr</td>
<td>47.069 bytes</td>
<td>5.60%</td>
</tr>
<tr>
<td>hantian</td>
<td>35.919 bytes</td>
<td>4.17%</td>
</tr>
<tr>
<td>vision.postech.ac.kr</td>
<td>6,216 bytes</td>
<td>0.72%</td>
</tr>
<tr>
<td>141.229.104.51</td>
<td>3,474 bytes</td>
<td>0.40%</td>
</tr>
<tr>
<td>knuth.postech.ac.kr</td>
<td>3,409 bytes</td>
<td>0.38%</td>
</tr>
<tr>
<td>PRLCDM1.postech.ac.kr</td>
<td>2,818 bytes</td>
<td>0.30%</td>
</tr>
<tr>
<td>indus.postech.ac.kr</td>
<td>2,004 bytes</td>
<td>0.24%</td>
</tr>
</tbody>
</table>
# Traffic Destination Analysis

![Traffic Destination Analysis](image)

## Data Received: Top 10 Hosts Information, TOP100, ALL

<table>
<thead>
<tr>
<th>Time</th>
<th>Now</th>
<th>Day View</th>
</tr>
</thead>
<tbody>
<tr>
<td>22:23</td>
<td>21:40</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitoring Time</th>
<th>Sun Nov 21 21:35:46 KST 1999</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Total size of data</th>
<th>Total number of packets</th>
<th>Total number of hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td>895,673 bytes</td>
<td>2,883</td>
<td>45</td>
</tr>
</tbody>
</table>

### Host Information
- hanlee.postech.ac.kr: 620,225 bytes (73.19%)
- hontan: 77,100 bytes (9.08%)
- viso.postech.ac.kr: 35,626 bytes (4.13%)
- angelo.postech.ac.kr: 29,930 bytes (3.48%)
- 256.265.255.255: 20,022 bytes (2.30%)
- vision.postech.ac.kr: 10,033 bytes (1.16%)
- 141.123.92.255: 5,758 bytes (0.67%)
- 141.123.92.256: 5,634 bytes (0.64%)
- 141.123.107.255: 4,074 bytes (0.47%)
- 141.123.121.255: 3,980 bytes (0.48%)
Source & Destination Analysis
Traffic Type Analysis (1)
Traffic Type Analysis (2)

![WebTrafMon](image)

### Protocol Information

<table>
<thead>
<tr>
<th>Time</th>
<th>00</th>
<th>01</th>
<th>02</th>
<th>03</th>
<th>04</th>
<th>05</th>
<th>06</th>
<th>07</th>
<th>08</th>
<th>09</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Now</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Monitoring Time:
Sun Nov 21 21:36:25 KST 1999

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Total size of data</th>
<th>Total number of packets</th>
</tr>
</thead>
<tbody>
<tr>
<td>tcp</td>
<td>678,294 bytes (78.67%)</td>
<td>2,187</td>
</tr>
<tr>
<td>udp</td>
<td>576,284 bytes (21.03%)</td>
<td></td>
</tr>
<tr>
<td>icmp</td>
<td>2,512 bytes (0.26%)</td>
<td></td>
</tr>
</tbody>
</table>
Traffic Type Analysis (3)
WebTrafMon Summary

- **WebTrafmon**
  - Web-based system
    - anytime, anywhere, anyone can use it easily
  - Shows host information
    - source, destination, source-destination pair
  - Shows protocol information
    - classified information per each network layer
  - Long term analysis as well as real-time term analysis

- Very portable
  - attach it to any network subnet and monitor

- Ideal to be used with **L4 switch**

- Very effective tools for detecting killer applications (e.g., MP3 & network game servers!)
iMON: Internet Server Monitoring System

- For continuously monitoring all internet and intranet TCP/IP services 24 hours a day
- iMON can check if e-mail servers, web servers, ftp servers, news servers, and any other TCP/IP based services are active and responding
- In the event of server failure, iMON can notify you in many ways such as pager notification, alert e-mail, audible and visible alert
- All of monitoring results can be accessed remotely through the Web
iMON Feature

- Runs on Windows 95/98/NT
- User-defined cycle interval per monitoring services
- State report with respect to Server Alive, Server Dead, Network Disconnected, monitoring exception
- History report based on daily, monthly, weekly, yearly
- Availability, Reliability Statistics report
iMON Architecture

Event notification

Retrieve monitoring result

Configure monitoring state

Polling

News Server

Web Server

Mail Server

FTP Server

DNS Server

Web Server

Database

Server Monitoring Program

Web Server

E-mail

Console

Pager

Web Browser

(109)

POSTECH DP&NM Lab
Status Report

모니터링 결과
현재 시간: 99-11-17 오전 7:23:59

Available | Unavailable | Dead | NotMonitored

관리되고 있는 서버의 개수: 6
가능을 수행하고 있는 서버의 개수: 6
History Report
Statistic Report
Web-based Internet/Intranet Mail Server Management System

- R&D project jointly pursued by POSTECH and KNU
- Applying Web, Java, SNMP technologies to manage mail server systems
  - Java-based manager
  - Mail service management functions (fault, configuration, performance)
  - SNMP agent implementing Mail Monitoring MIB (RFC 2249)
  - Web server for downloading Java applets
  - Web browser user interface to human managers
Mail Server Management System Architecture

- Web Browser
  - Java GUI Modules
  - SNMP Applet Client
- Web Server
  - HTML Files
  - SNMP Applet Server
- MTA Manager System
- MTA Agent System
  - RFC 2248
  - RFC 2249
  - MIB
- Mail Server Process
- MIB Generator
- Mail log file

Connections:
- Download
- GET/SET
- TRAP
- HTML Files
- Trap Server
- SNMP Applet Server
- SNMP Applet Client
- Java GUI Modules
- GET/SET
- MTA Agent
- Mail Server Process
- MIB Generator
- Mail log file
Mail Server Current Status Monitoring

SMTP Server: tigris.postech.ac.kr

Current Status Information

- General Information
  - SMTP host name: tigris.postech.ac.kr
  - IP address: 141.223.82.15
  - SMTP server: Sendmail 8.8.8

Message Status

- Recipient Status
- Received Messages
- Stored Messages
- Transmitted Messages

Error Status

- Inbound Error Count
- Internal Error Count
- Outbound Error Count

Conversion Status

- Successfully Converted Messages
- Failed Converted Messages
Mail Server MIB Browser
Mail Server Trap Setting & Information

SMTP Server: tigris.postech.ac.kr

<table>
<thead>
<tr>
<th>IP ADDRESS</th>
<th>SMTP Server</th>
<th>STATUS</th>
<th>Agent Starts</th>
</tr>
</thead>
<tbody>
<tr>
<td>141.223.82.15</td>
<td>Sendmail 8.8.8.8/8.8.8</td>
<td>Running</td>
<td>Fri Jul 24 13:10:12 KST 1996</td>
</tr>
</tbody>
</table>

Trap Condition Information

- Trap Setting Status

<table>
<thead>
<tr>
<th>Current</th>
<th>Threshold</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>120</td>
<td>NoError</td>
</tr>
<tr>
<td>0</td>
<td>222</td>
<td>NoError</td>
</tr>
<tr>
<td>0</td>
<td>99</td>
<td>NoError</td>
</tr>
<tr>
<td>0</td>
<td>2222</td>
<td>NoError</td>
</tr>
<tr>
<td>0</td>
<td>24</td>
<td>NoError</td>
</tr>
</tbody>
</table>

View result

Tue Jul 20 20:35:31 GMT 1995
Object ID: 1, iso, org, dod, internet, mgmt, mib-2, mta, mtaTable, mtaEntry, mtaFailedConvertedMessageCounter: 0

Tue Jul 20 20:31:38 GMT 1995
Object ID: 1, iso, org, dod, internet, mgmt, mib-2, mta, mtaTable, mtaEntry, mtaFailedConvertedMessageCounter: 0

Tue Jul 20 20:31:19 GMT 1995
Object ID: 1, iso, org, dod, internet, mgmt, mib-2, mta, mtaTable, mtaEntry, mtaFailedConvertedMessageCounter: 0

Tue Jul 20 20:31:04 GMT 1995
Object ID: 1, iso, org, dod, internet, mgmt, mib-2, mta, mtaTable, mtaEntry, mtaFailedConvertedMessageCounter: 0

Tue Jul 20 20:31:04 GMT 1995
Object ID: 1, iso, org, dod, internet, mgmt, mib-2, mta, mtaTable, mtaEntry, mtaFailedConvertedMessageCounter: 0

Tue Jul 20 20:31:04 GMT 1995
Object ID: 1, iso, org, dod, internet, mgmt, mib-2, mta, mtaTable, mtaEntry, mtaFailedConvertedMessageCounter: 0

Tue Jul 20 20:31:04 GMT 1995
Object ID: 1, iso, org, dod, internet, mgmt, mib-2, mta, mtaTable, mtaEntry, mtaFailedConvertedMessageCounter: 0

Tue Jul 20 20:31:04 GMT 1995
Object ID: 1, iso, org, dod, internet, mgmt, mib-2, mta, mtaTable, mtaEntry, mtaFailedConvertedMessageCounter: 0
Mail Server Performance Monitoring

SMTP Server: tigris.postech.ac.kr

Menu:
- Current Status
- MB Browser
- Trap Condition
- Performance
- Return to Home...

Performance Information:

- Conversion Status:
  - Successful Converted Messages
  - Failed Converted Messages

- Error Status:
  - Inbound Error Count
  - Internal Error Count
  - Outbound Error Count
TMN-based Integrated Network Management using Web Technology

- R&D project jointly pursued by Korea Telecom NMTL, POSTECH and KNU
- Applying TMN, Web, CORBA, Java technologies to integrate existing NMSs in Korea Telecom
  - CORBA-based Inter-domain (CMIP, SNMP, CORBA, other) manager
  - TMN management functions (alarm surveillance, traffic monitoring, etc.)
  - Java-based management applications
  - Web server and browser
CORBA-based Inter-domain Manager Using Web

- HTML
- JAVA Applet
- JAVA Applet
- WEB Browser

- HTTP (CGI)
- CORBA (OrbixWeb)
- RMI

- Object Request Broker (ORB)

- CORBA/SNMP gateway
- CORBA/CMIP gateway

- SNMP Sub-domain
- CORBA Sub-domain
- CMIP Sub-domain

- Agent
- Agent
- Agent
- Agent
- Agent
- Agent
Target System Structure

Web Browser
Java Applet
Object Request Broker (ORB)

Management Functions
- Fault
- Configuration
- Account
- Performance
- Security

Protocol Gateway
- SNMP G/W
- CMIP G/W
- Other G/W

SNMP Devices
CMIP Devices
Other Devices

Protocol Gateway
- Metadata Repository
  - Specification Gateway (IDL Compiler)

Web Server

HTTP

SMI
GDMO
Other
Example of Alarm Surveillance System

![Diagram of Alarm Surveillance System]

- **Web Browser**
- **Java Applets**
- **Web Server**
- **Management Application**
- **ORB**
- **Management Information (log, html)**
- **HTTP**
- **IIOP**
- **WBM Server**
- **Management Services**
  - Alarm Surveillance Service
  - Fault
  - Config.
  - Account
  - Perform.
  - Security
- **Proxy Coordinator**
  - SNMP Gateway
  - CMIP Gateway
  - Other Gateway
- **SNMP Agent**
- **CMIP Agent**
- **Proprietary Agent**
GUI of Alarm Surveillance System
POS-EWS for WebMUI

- Developing EWS for providing WebMUI of Hana Systems Rustle 4501 Internet router
  - http://dpnm.postech.ac.kr/ews  http://www.hanasys.co.kr
- Supports the following features
  - multiple simultaneous users
  - run on various embedded OS platforms
  - interface to SNMP agent
  - lightweight - requires various little resources
  - HTTP 1.1
  - Server Side Include (SSI)
- EWS on an ASIC chip?
POS-EWS

- Single thread, ROM File system, ASP like Server Side Script
- Executable Image size - typically 80K bytes
- a: static, b: dynamic, c: dynamic & SNMP, d: real-time & SNMP

Diagram:

- Web Browser
- Java
- POS-EWS
- HTML
- Java
- Embedded Application
- SNMP Agent
Summary

- Problems with current management approaches
  - many incompatible frameworks
  - no common foundation, no consistent view
- Integration of existing NMSs and frameworks is essential but challenging
- WBEM and JMX are NOT silver bullets
- EWS technology is very useful for Internet device management
- Web technology combined with CORBA/Java is a good foundation for an integrated solution
- Industry is taking this approach very seriously
Future work (1)

- Scalability?
  - e.g., can we manage tens of thousands of devices using WBM?
- Can we do it with a single manager? Multiple managers? How do managers cooperate?
- Reliability?
- Performance?
  - Efficient and Reliable Alarm Reporting?
  - Audible sound, colored icons, visible blinking on user monitor
  - Email, pager, fax, cellular phone
Future work (2)

Integration with existing network management systems?
- Is this desirable?
- Is this possible?
- What are the possible ways?

Network management of EWS-equipped network devices
- What if some of them are equipped with SNMP agent only?
- What if some of them are equipped with EWS only?
- What if some of them are equipped with both SNMP agent and EWS?
Useful References (1)

- **Web-based Management**
  - http://dpnm.postech.ac.kr/wbm/

- **WBEM**
  - http://wbem.freerange.com/
  - http://www.freerange.com/wbempdk
  - http://www.dmtf.org/cim
  - http://www.rational.com/uml

- **WebTrafMon**
  - http://dpnm.postech.ac.kr/webtrafmon
Useful References (2)

- **JMAPI**

- **MRTG+**
  - http://dpnm.postech.ac.kr/MRTG
  - http://ee-staff.ethz.ch/~oeiker/webtools/mrtg/mrtg.html

- **MAESTRO Multimedia System & Management**
  - http://dpnm.postech.ac.kr/maestro
  - http://dpnm.postech.ac.kr/CorbaMan

- **Internet/Intranet Network, Application Service Management**
  - http://dpnm.postech.ac.kr/internet
Useful References (3)

- **Embedded Web Server Technology for Web-based Management**
  - http://dpnm.postech.ac.kr/ews
  - http://www.w3c.org
  - http://www.emweb.com
  - http://www.magmainfo.com
  - http://www.bvmltd.co.uk/intrascada_ds.html
  - http://www.reflex-tech.co.uk/info/eneaweb.htm
  - http://www.atinucleus.com/intro.htm
  - http://www.ussw.com/home