

Remote Fiber Optic Health Monitoring: Evaluation of a High Performance Steel Bridge

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Challenges with Remote Health Monitoring

- Equipment limitations
 - Data transmission.
 - Computing processing power.
 - Environmentally fragile sensors.
- Data reduction and storage issues.
- Cost.



Health Monitoring of a High-Performance Steel Bridge



83rd Annual TRB Meeting

Health Monitoring of a High-Performance Steel Bridge

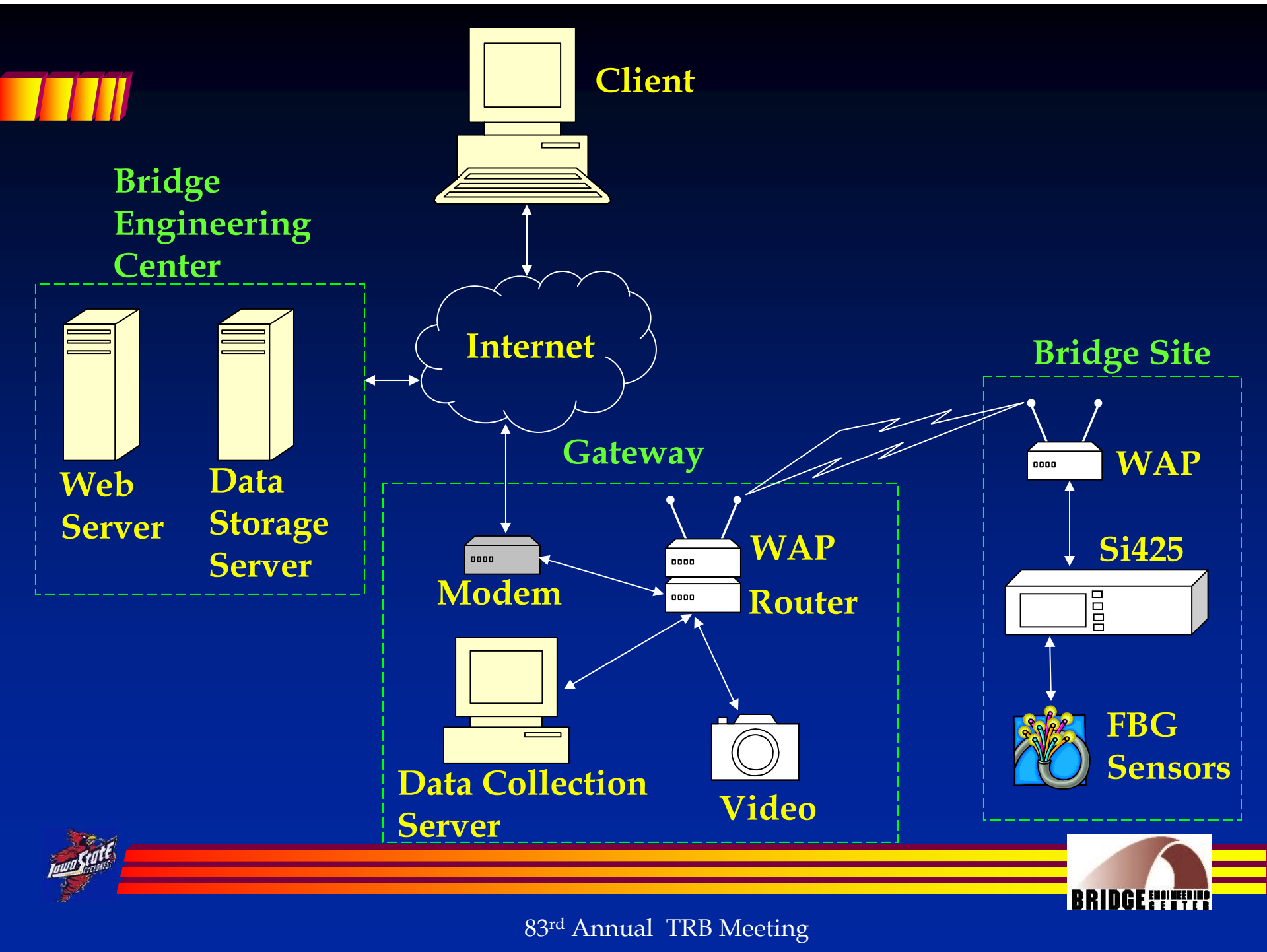
- Purpose of monitoring:
 - Assess long-term performance
 - » Changes with time.
 - » Structural characteristics.
 - Measure and quantify fatigue loadings.
 - Assess serviceability associated with “lighter” design.



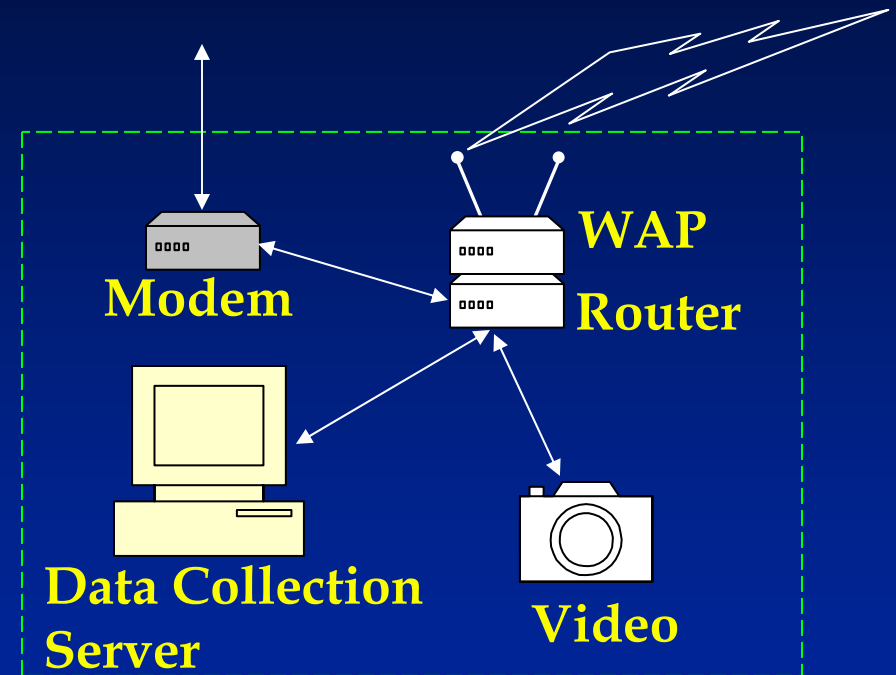
East 12th Street Health-Monitoring System

- Components:
 - 30 FBG optical sensors.
 - Swept laser interrogator (Unix based).
 - Web server.
 - Data collection server (DCS).
 - Data storage server (DSS).
 - Video camera.
 - Wireless networking components.





WAN/LAN Gateway



WAN/LAN Gateway

- Network
 - Standard DSL modem and line
 - » Port-forwards all port requests to router.
- Data Collection Server (DCS)
 - 700 MHz Pentium III Processor.
 - 256 MB RAM.
 - 8.0 GB Hard drive.
- Universal power supply
 - Backup power for up to 25 minutes.



WAN/LAN Gateway

- Video Camera:
 - Canon Network Camera VB-C10/VB-C10R.
 - Adjustable video quality and frame rate.
 - 16x zoom lens.
 - Remote camera control utility.
 - Built-in web server and FTP server.

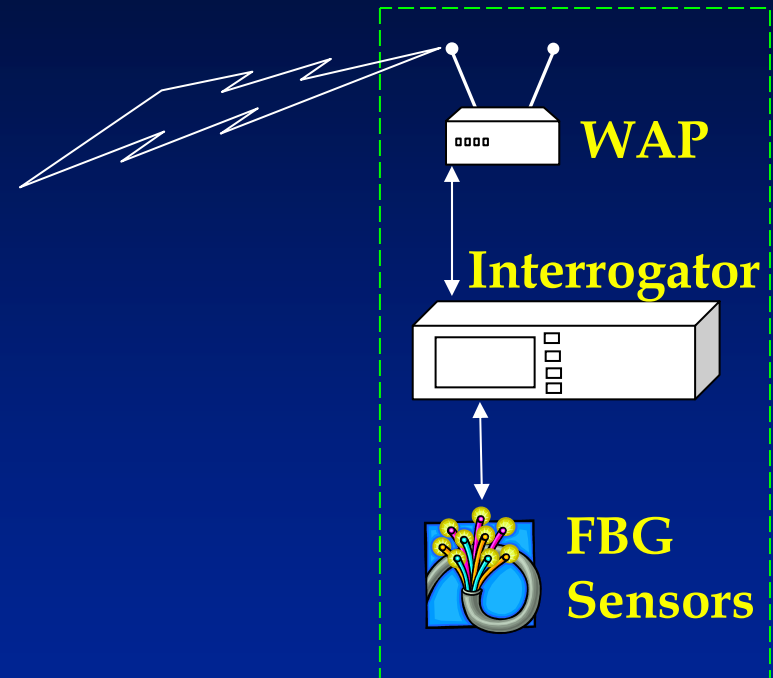


WAN/LAN Gateway

- Wireless Router and Access Points:
 - Linksys 2.4 GHz Wireless-802.11g Router
 - Linksys 2.4 GHz Wireless-802.11g Access Point
 - Data transfer rate = 54 Mbps
 - 128-bit WEP encryption, MAC or IP address filtering



Bridge Site System Components



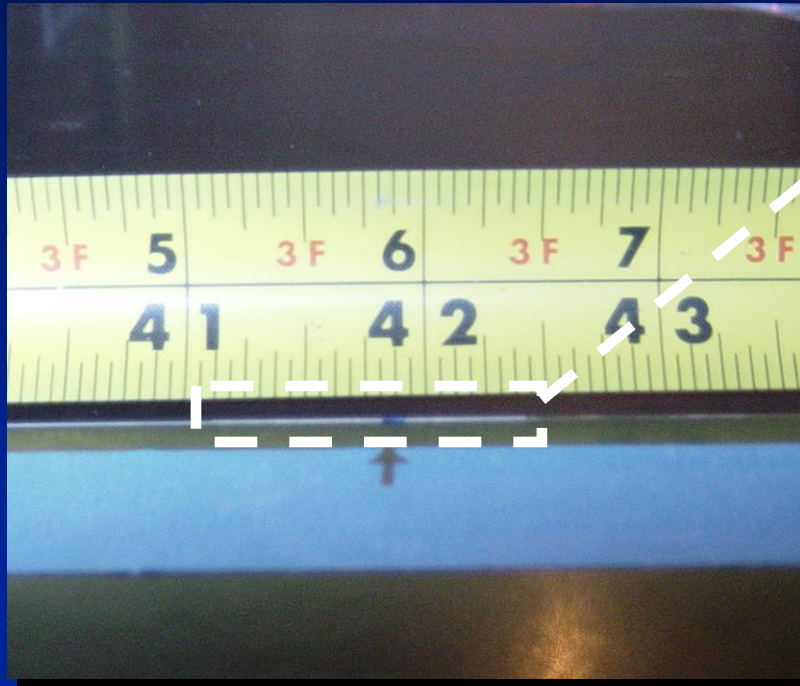
Bridge Site System Components

- Swept laser interrogator
 - Simultaneously monitor up to 512 sensors
 - » 4 channels @ 128 sensors/channel.
 - Scan speeds up to 250 Hz.
 - Standard Ethernet port for access and control.
 - Built-in single-board computer and display.



Bridge Site System Components

- Fiber Bragg Grating (FBG) Sensors →



Bridge Site System Components

- Fiber Bragg Grating (FBG) Sensors
 - Immune to EMI/RF interference.
 - Measure wavelength shift.
 - Form part of the data transmission optical fiber.
 - Not electrically conductive.
 - Low signal loss with long lead lengths.
 - Can be serially multiplexed.

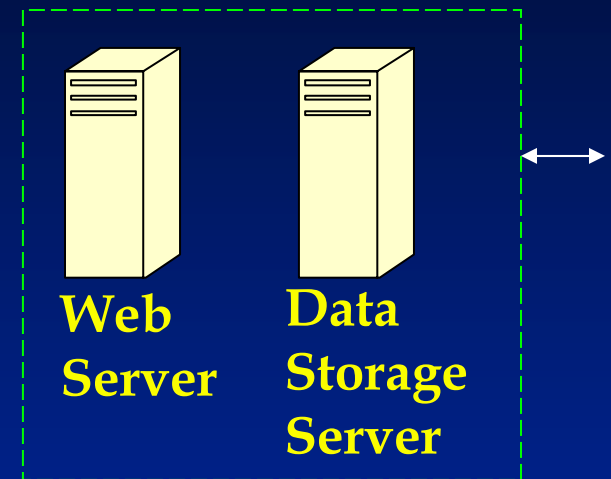


Bridge Site System Components

- Wireless Access Point.
- Universal power supply
 - Backup power for up to 100 minutes.
- Protective housing unit
 - Stores interrogator, WAP, and UPS.
 - Temperature controlled via thermostat, heaters, insulation, fans, etc.



BEC System Components



BEC System Components

- Web server.
- Data Storage Server (DSS)
 - 3.0 GHz processor.
 - 1.2 TB Hard drive (RAID 5).
 - 4.0 GB RAM.



File Transfer Protocol

- DCS saves strain data in 100 MB files
 - Generated \approx 40 minutes.
- 100 MB files automatically compressed to 10 MB files.
- DSS automatically retrieves 10 MB files from DCS (\approx 6 minutes to transfer).
- DSS utility unzips and stitches files into larger, useful packets.



Web Portal


Structural Health Monitoring [I-235 and E. 12th Street Bridge, Des Moines, Iowa] - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Search Favorites Media Print AutoFill Options

Address <http://www.cbre.iastate.edu/nick/HPS.htm> Go

Google Search Web 275 blocked AutoFill Options



BRIDGE ENGINEERING CENTER

Timber Bridge Program

Structural Health Monitoring

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[[Sensor List](#) | [Overview](#)]




Camera: Image1



WebView
Livescope

Start Control



Microstrain (in/in)

Stop

Connection established.
Current Channel: 1

start Internet 3:12 PM



Packet Analyses

- Stress cycle counting
 - Rain flow analysis.
- Separation of vehicle/environment induced strain.
- Formulation of temperature/ strain relationships
 - Nonlinear, multivariate analysis.
- Estimation of transient load characteristics.
- Comparison with point-in-time controlled tests.



Concluding Remarks

- Standard DSL adequate for data transfer
 - Possible via compressed partial file transfer and stitching utility.
- Verified real-time WWW interactive video and strain display.
- Success with off-the-shelf wireless networking equipment.
- Testing has proven system stability.



Acknowledgements

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