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.

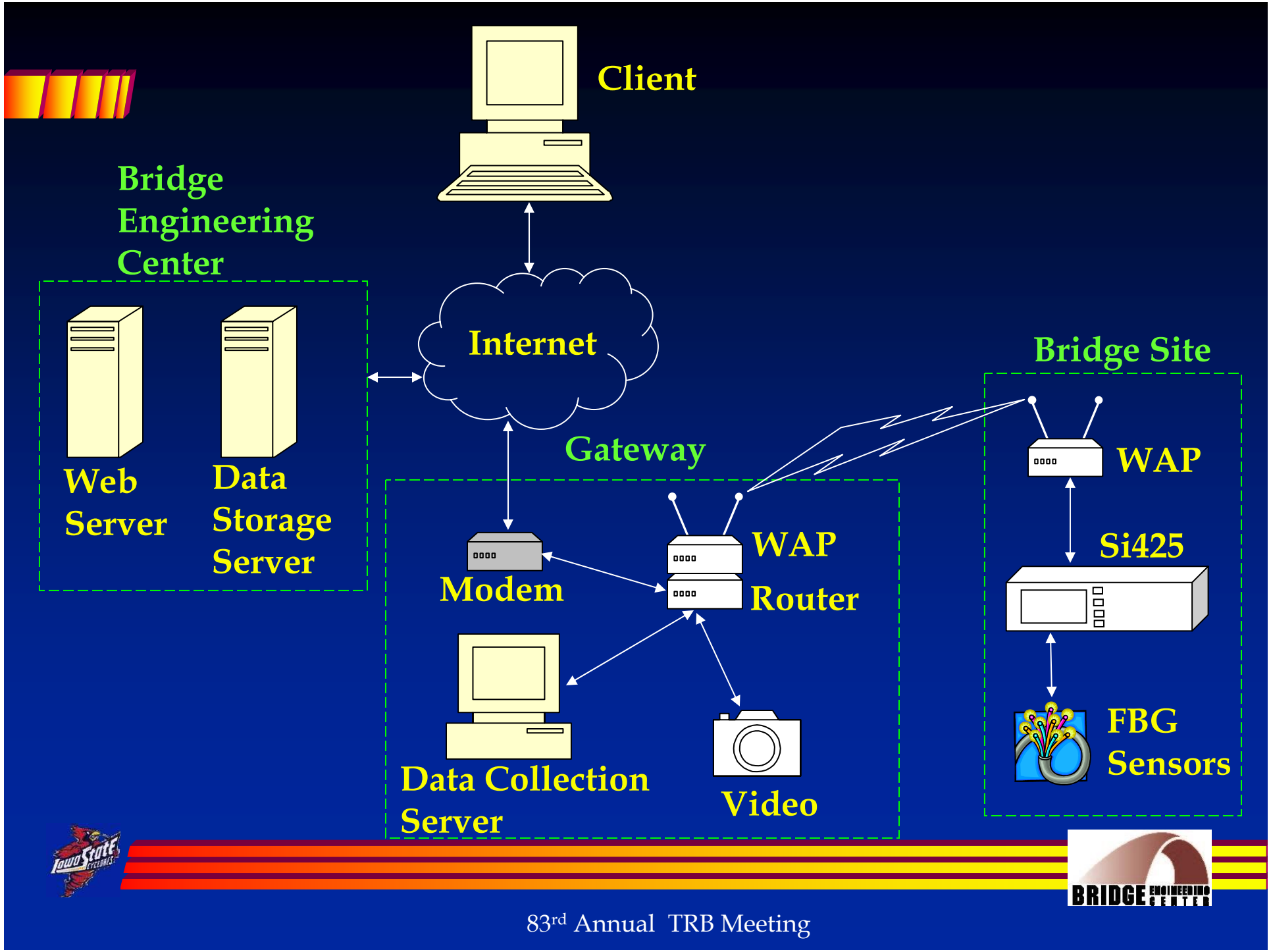
Health Monitoring of a High-Performance Steel Bridge

Health Monitoring of a High-Performance Steel Bridge

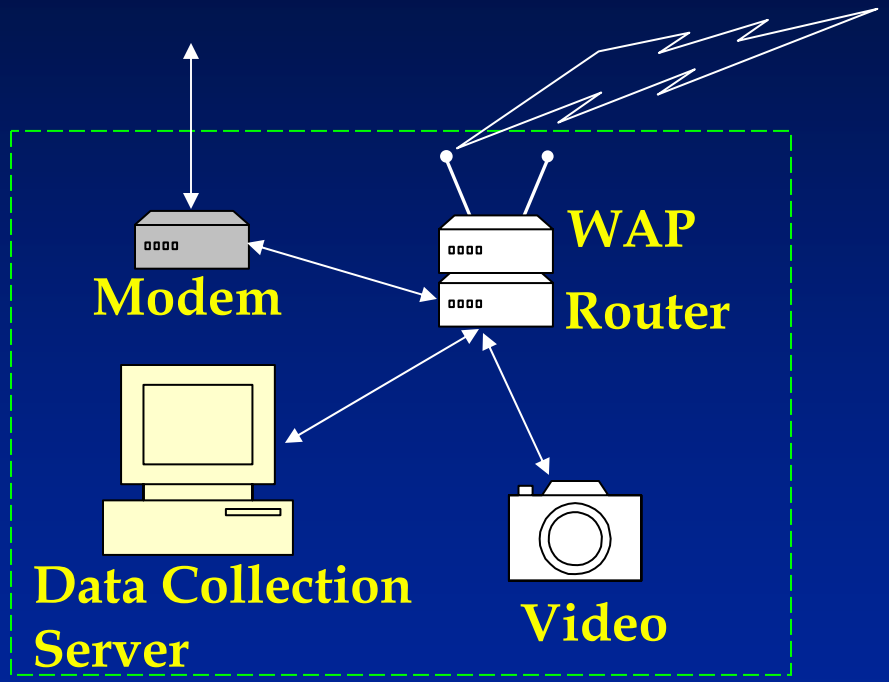
- Purpose of monitoring:
  - Assess long-term performance
    - » Changes with time.
    - » Structural characteristics.
  - Measure and quantify fatigue loadings.
  - Assess serviceability associated with "lighter" design.

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.


Client
Bridge Engineering Center
Internet
Web Server
Data Storage Server
Gateway
Bridge Site
WAP
Modem
WAP Router
Si425
Data Collection Server
Video
FBG Sensors

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.

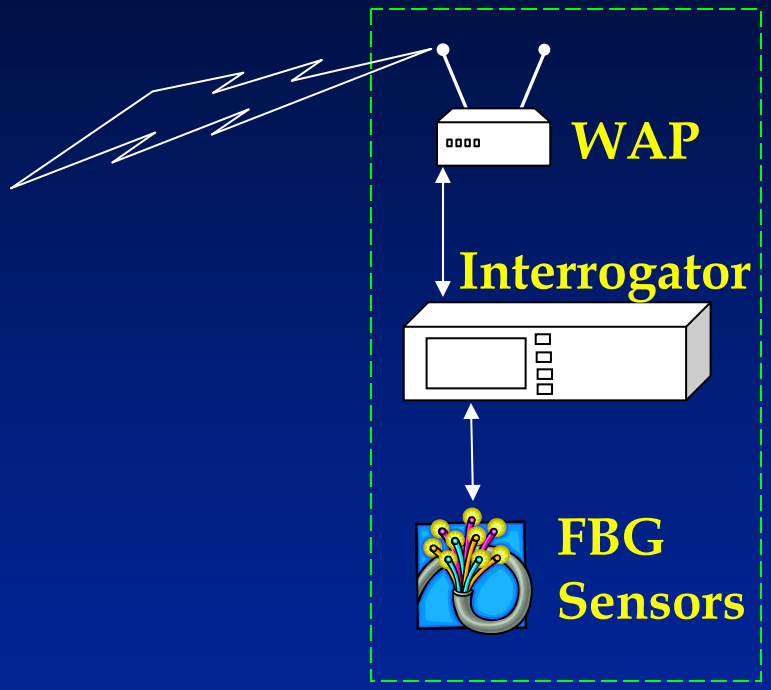
WAN/LAN Gateway

- 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

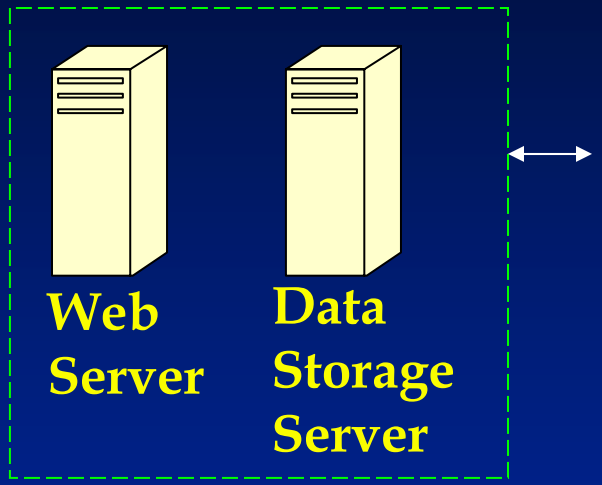
Bridge Site System Components

- 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



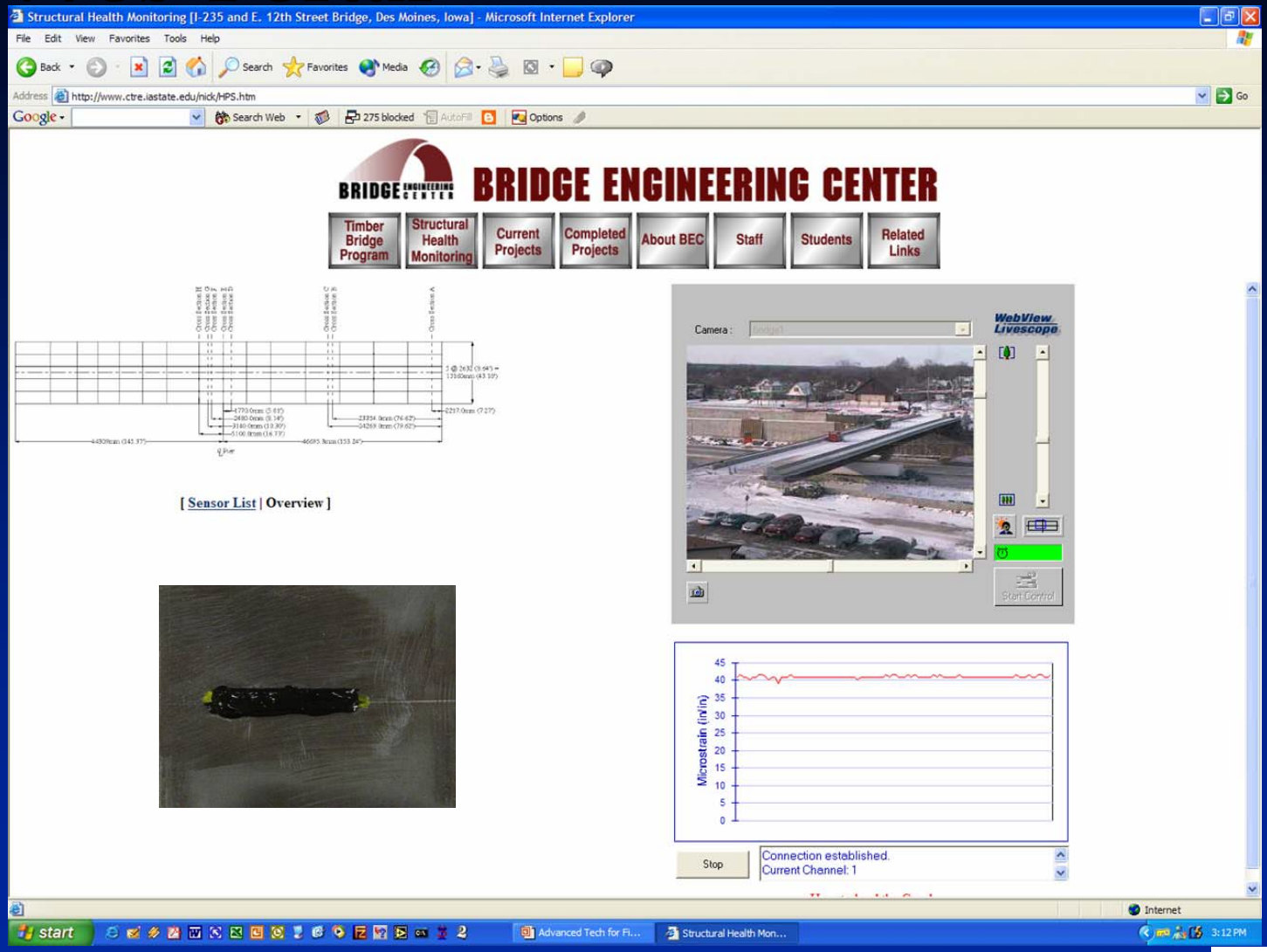
BEC System Components

- 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 ≈ 40 minutes.
- 100 MB files automatically compressed to 10 MB files.
- DSS automatically retrieves 10 MB files from DCS (≈ 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
http://www.ctre.iastate.edu/nick/HPS.htm
BRIDGE ENGINEERING CENTER
Timber Bridge Program
Structural Health Monitoring
Current Projects
Completed Projects
About BEC
Staff
Students
Related Links
[Sensor List | Overview]
Camera :
WebView Livescope
Start Control
Microstrain (in/in)
Stop
Connection established.
Current Channel: 1
Internet
start
Advanced Tech for Fi...
Structural Health Mon...
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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