

Distributed Fiber Optic Sensing and Network Applications

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- ❖ Network Applications
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Fiber Optic Sensing Fundamentals

Light in the optical fiber has many properties

Intensity

Wavelength/
frequency

Spectral
distribution

Absorption

OAM state
(orbital angular momentum) ...

Phase

Polarization

Mode
coupling

Fluorescence

Scattering

They can be used to measure many physical phenomena

Temperature

Pressure

Vibration

Acoustic wave

Shape

Position ...

Strain

Displacement

Acceleration

Chemical ...

Fiber optic sensor offers many benefits

High sensitivity

Long
sensing
length

Compact

Remote
monitoring

Distributed,
multi-point,
single-point

Low
latency

Passive

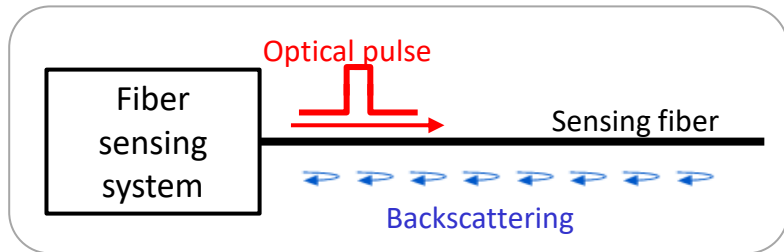
Immune to
interferences
(e.g. EMI)

Light weight

Ultra harsh
environment

Simultaneous
multi-phenomena
detection ...

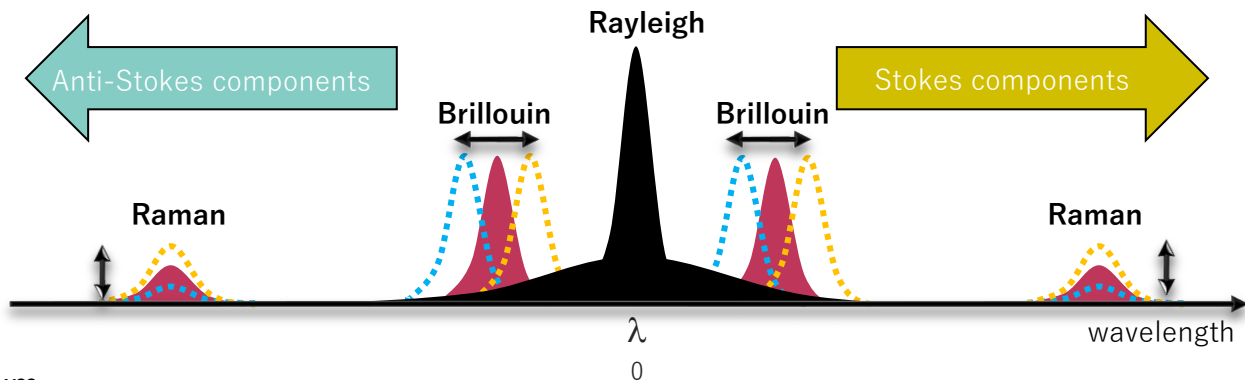
Principle of Distributed Fiber Optic Sensing



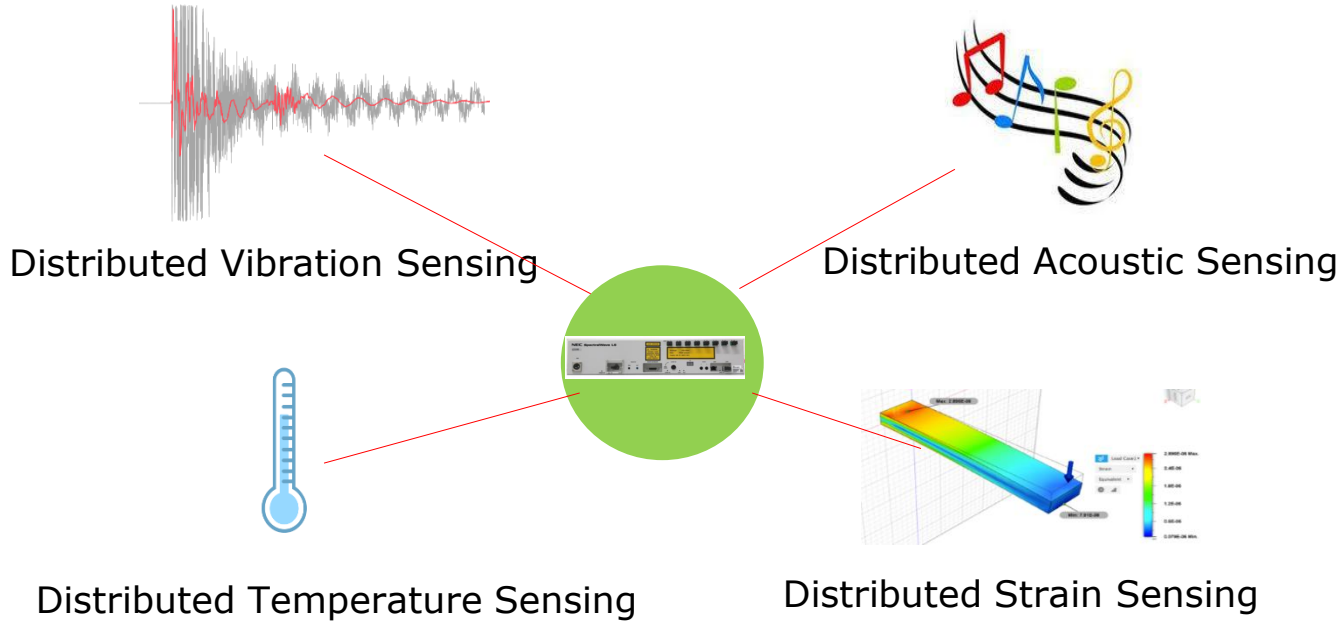
Backscattering for applications

- **Raman:** temperature (DTS)
- **Brillouin:** temperature and strain (DTSS, BOTDR)
- **Rayleigh:** vibration/acoustic (DAS, DVS)

Optical back-scattering



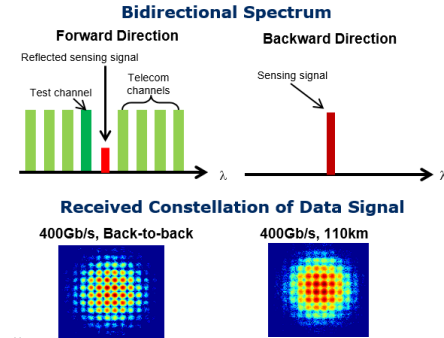
NEC Distributed Optical Fiber Sensor Platform



Sensing Over Communication Channel



NEC SpectralWave LS DAS



Network As a Sensor



Point Sensor



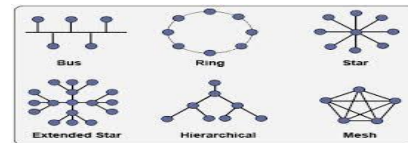
Fiber / Cable



Linear Sensor



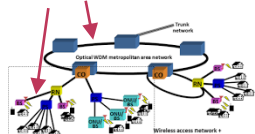
Communication Networks



Communication/Sensing



Sensor: Network connections and Routes



Network Sensing

Network As a Sensor

Applications Enabled by Fiber Sensing

Fiber Sensing System



Data Collection (Sensing)



AI Models (Understanding)



User Interface (Visualization)

1

Facility Security



Network Equipment



Key Facility



Perimeter Intrusion

2

Field Operations



Cable Fault Location



Anomaly Detection

4

Road Constructions



Cable Cut Prevention

3

Structure Health



Pole Integrity, Road Surface, Building

5

Traffic Management



Traffic Monitoring

6

Environmental Monitoring



Earthquake



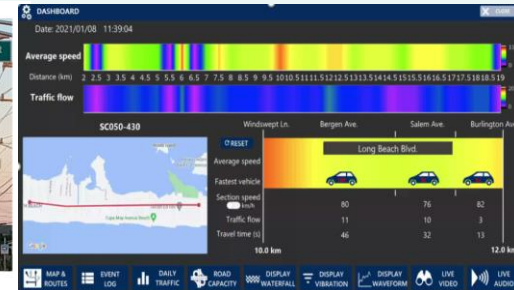
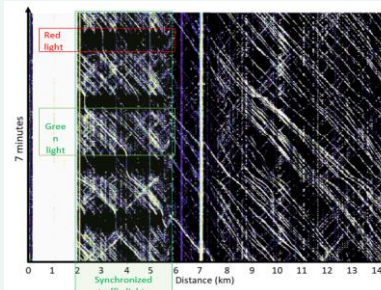
Using Network Infra For Environmental Sensing

Applications for Traffic Monitoring

Traffic Management:

- Number of vehicles
- Individual vehicle speed and average speed
- Congestion level
- Vehicle type & weight information

Speeding !



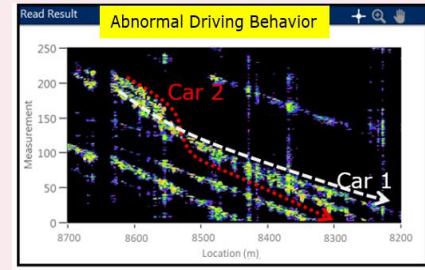
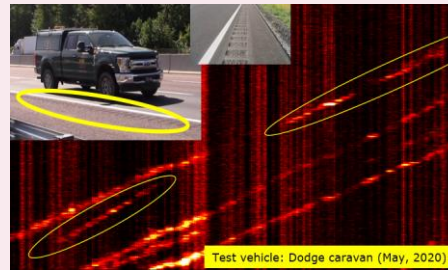
Anomaly Detection:

- Traffic accident
- Wrong-way driving
- Suspicious/dangerous driving patterns
- Flat tire and tire condition
- Emergency stop

Tire Condition

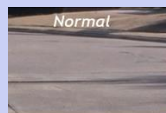


Wrong Way Driving



Road Structure & Vehicle Health Monitoring:

- Road surface condition (temp. → surface icing)
- Construction monitoring
- Bridge and tunnel
- Vehicle suspension check



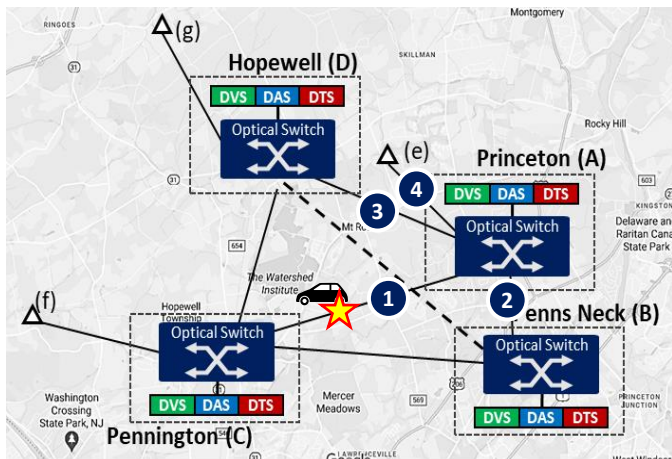
Road surface condition



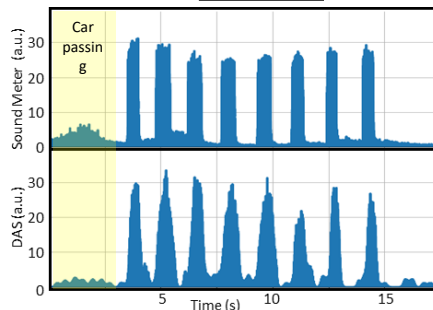
Distributed Fiber Optic Sensing over Network Infrastructure

- Multiple parameters (vibration, temperature, sound) can be monitored over networks with different topologies (star, ring, mesh, etc.)

Existing Telecom Network (NJ, USA)

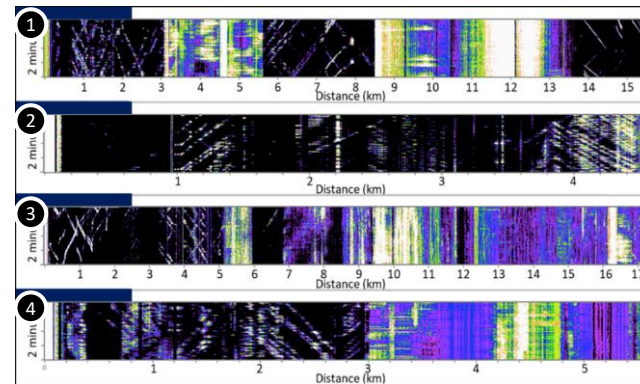


Car horns

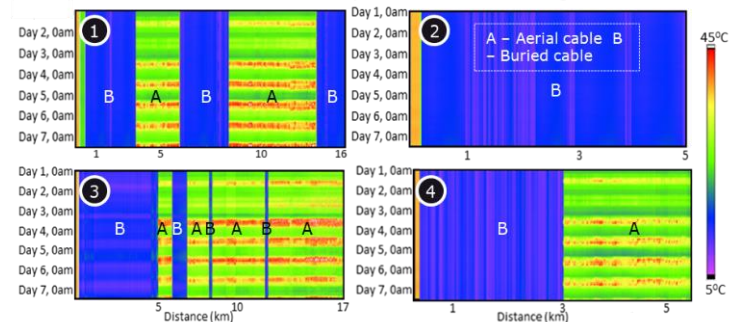


DTS: Distributed Temperature Sensing
 DAS: Distributed Acoustic Sensing
 DVS: Distributed Vibration Sensing

Road Traffic

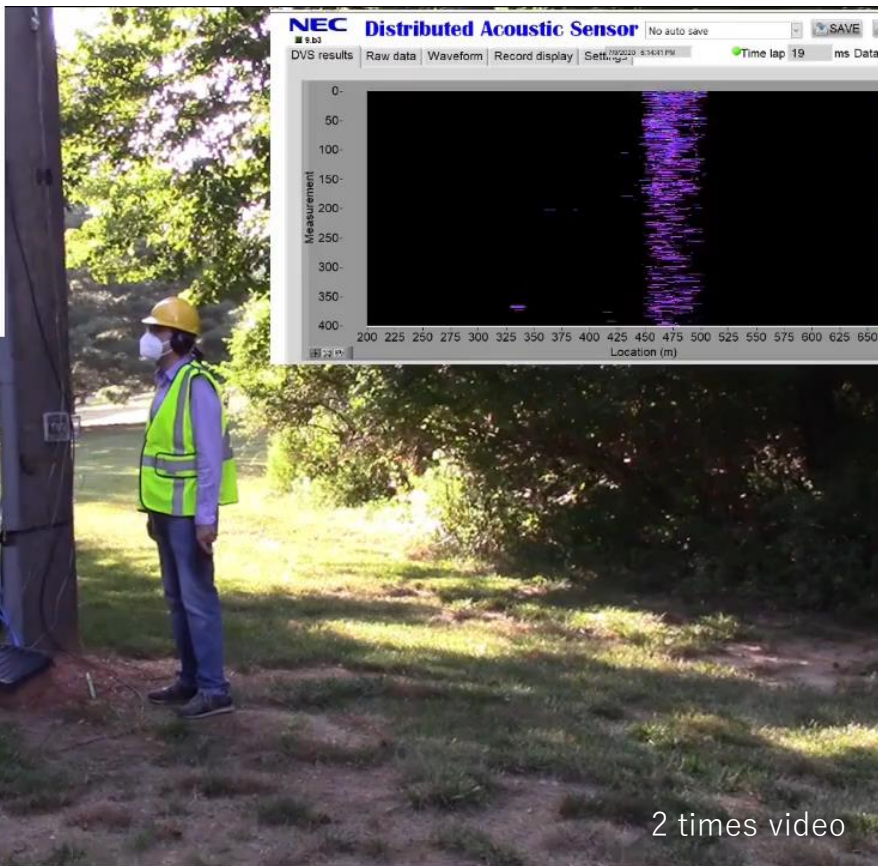
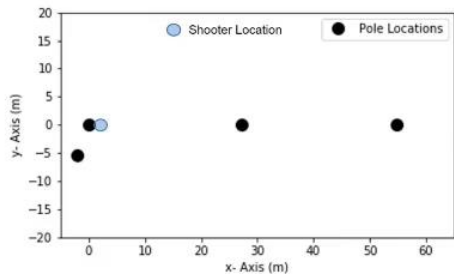


Environmental Temperature Monitoring



Gun-shot Localization Over Telecom Network (Network as a Sensor)

Top View of the Test Bed



2 times video

Conclusion

- ❑ Utilizing optical fiber as a sensing media
- ❑ Distributed fiber sensing with multiple physical sensing parameters
- ❑ Optical network infrastructure as a sensor
- ❑ AI and machine learning play a key role on sensing data processing and understanding
- ❑ Exploring more use cases and providing real benefits to network service providers and society (smart city applications)

Thank You !