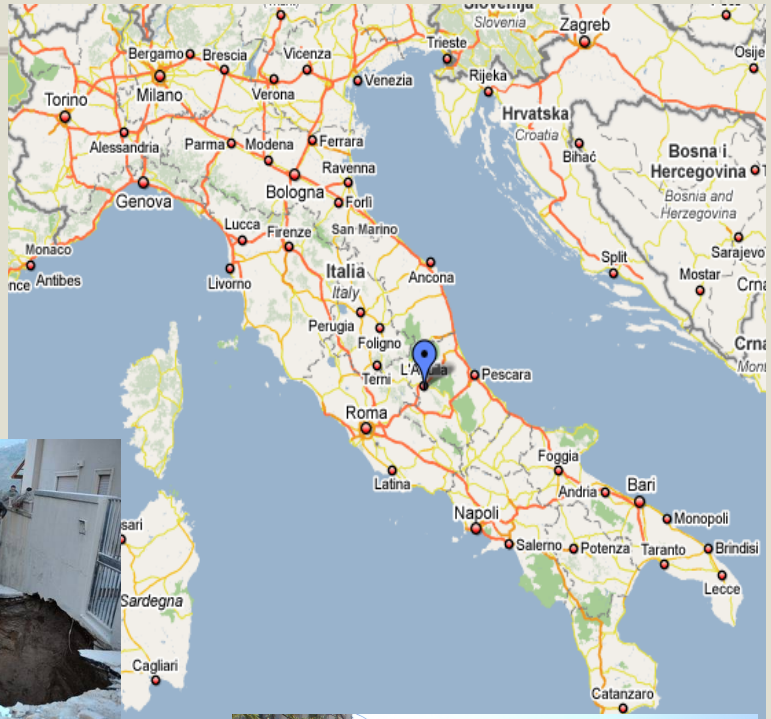
INCIPICT

INnovating CIty Planning through Information and Communication Technologies

From the April 6th 2009 earthquake to now

- More than 300 people killed
- Many historical buildings destroyed
- Six years later
- L'Aquila as an open area for experimental projects' test beds
- the INCIPICT project is only one of them
- INCIPICT, 5M€ fundings
- Constructuion of an experimental optical network for the city
- Design of an innovative communication network
- Implementation of advanced services



INCIPICT PA work package

- **PA:** Development of a metropolitan area network and services for Public Administration, research and innovation
  - Optical ring deployment
  - Dematerialization of PA documents
  - Management and continuity of operations of PA in emergencies

INCIPICT ROS & WIR work packages

- **ROS:** Development of an experimental optical network
  - Energy efficiency of the access optical network
  - Innovative solutions for METRO networks
- **WIR:** Innovative persvasive wireless technologies
  - Energy efficiency and low complexity in physical layer techniques
  - QoE-based network coding techniques
  - Cognitive networks towards energy efficiency in next generation wireless networks
  - Distributed localization
  - Wide deployment of Wireless Sensor and Actuator Networks

ROS Contributors' Skills and Expertise

- Main research areas
  - Fiber-optic propagation modeling (UnivAQ);
  - Photonics device modeling (UnivAQ);
  - Optical networking (CNIT, Pisa);
  - Optical Access (CNIT, Pisa);

- Main research & development activities in these areas
  - Capacity limits of the fiber-optic transport network;
  - Space-Division Multipled (SDM) transmissions over multi-mode fiber optic structures;
  - Modeling of semiconductor-optical amplifier-based devices for local-area and long-haul communications;
  - Software-defined networking (SDN);
  - Efficient solutions for local area networking, cloud computing, data centers, and 5G wireless network backhauling.

- Significant Bibliography (a part of)
  - C. Antonelli, A. Mecozzi, M. Shtaif, and P. J. Winzer, "Stokes-space analysis of modal dispersion in fibers with multiple mode transmission," Opt. Express, vol. 20, pp. 11718–11783, 2012.
  - C. Antonelli and A. Mecozzi, "Reduced model for the nonlinear response of reflective semiconductor optical amplifiers," IEEE Photon. Technol. Letters, vol. 25, pp. 2243–2246, 2013.
  - Sgambelluri, A.; Giorgetti, A.; Cugini, F.; Paolucci, F.; Castoldi, P. "Open Flow-based segment protection in Ethernet networks", Optical Communications and Networking, IEEE/OSA Journal of Volume: 5 , Issue: 9, 2013.

Experimentation laboratory of the ROS outcomes

The fiber-optic ring will serve as a test-bed for the implementation and/or analysis of:

- Software-defined-network schemes for flexible resource allocation and service provisioning;
- Innovative optical access schemes;
- Distributed data-center architectures;

ROS - Related Projects

- PRIN 2010-2011: *Optical frequency/wavelength division multiple access techniques for Next Generation Networks* (ROAD-NGN), http://www.roadngn.uniroma3.it/index.html .
- Ends: February 2016
- Global funding: 840.000€

- DARPA BAA-13-20: *Exploration of Single –chip Phase -sensitive Amplifier*
- Ends: December 2015
- Global funding: 300.000$

WIR: Innovative wireless technologies

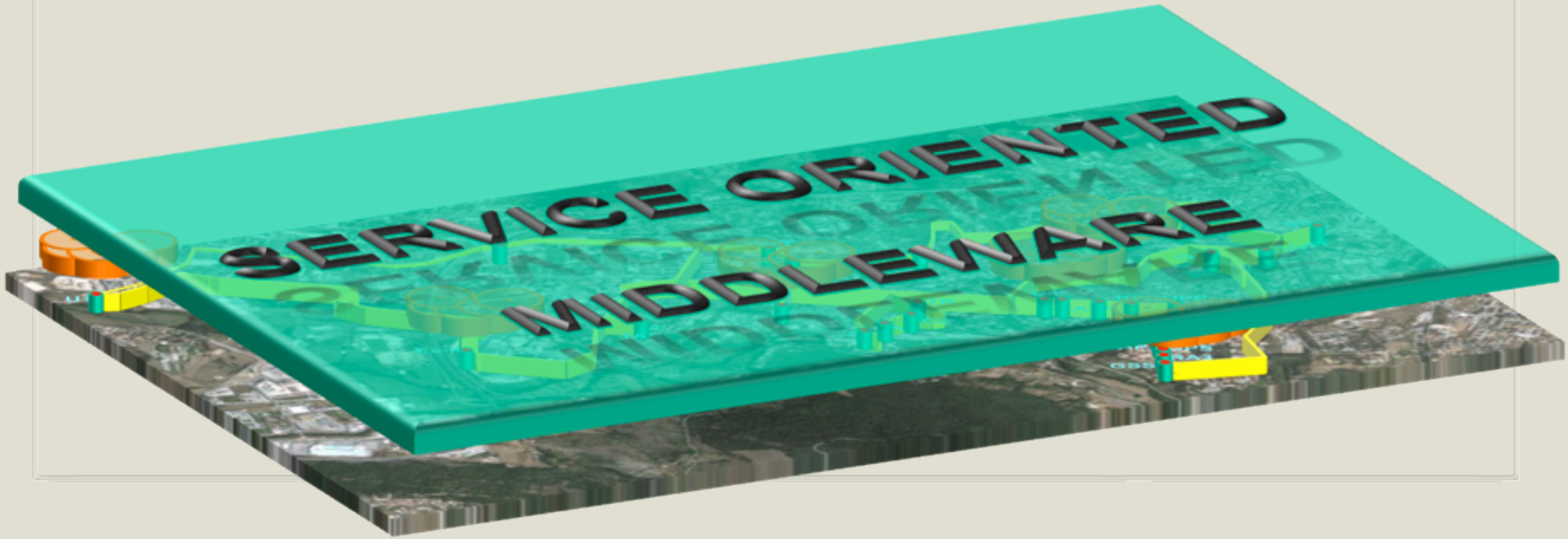
- **Harness the random behavior of wireless channels via *Space Modulation***
  - same data rate and end-to-end performances of MIMO schemes
  - reduction of transmission power and computational complexity
  - savings in energy (radio applications)
  - opportunistic schemes for the allocation of power (random behavior)

- **Network Coding**
  - mediation of incoming packets instead of simple retransmission (e.g., merge, reorder)
  - computational efficiency and robustness of the network dynamics
  - reduction of energy consumption of the wireless communication

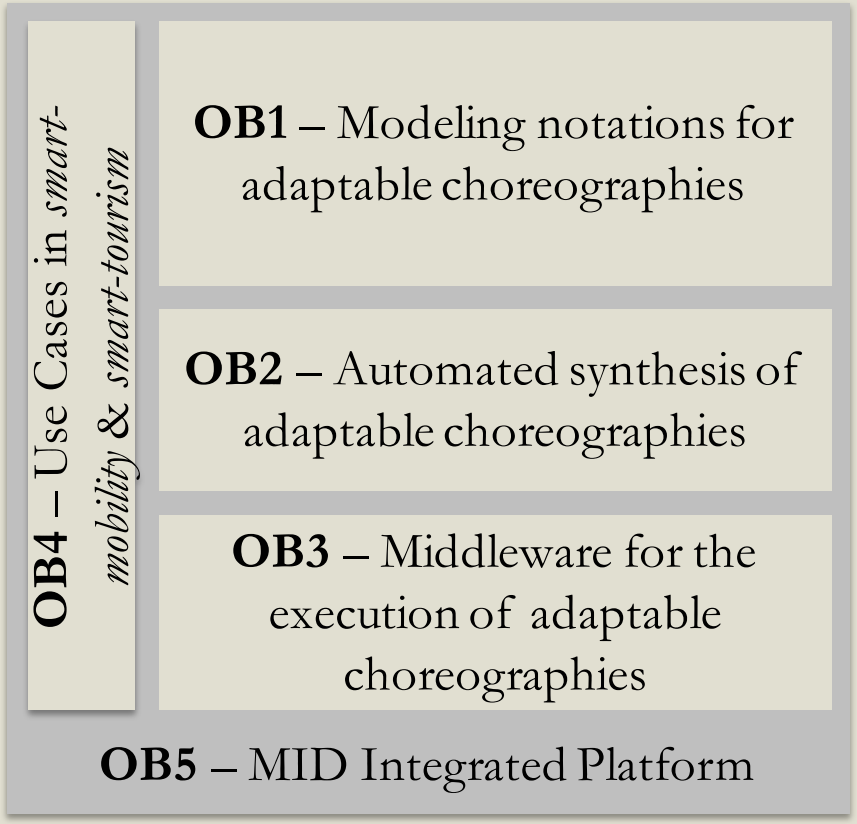
- **Support layer for innovative applications**
  - real time tracking and localization (network or satellite)
  - health care systems offering outpatient services
  - location-based emergency-management services
  - proximity location services can direct the users at the nearest place for the first assistance

INCIPICT MID work package

- **MID:** Middleware for dynamical coordination of heterogeneous software services
  - Design and coordination of dynamic software services (through a specific framework) by exploitation of the service choreography technique
  - Non-expert users (e.g. tourists) can indirectly specify the cooperation between services that can be necessary to satisfy their needs
  - Tools will be available in order to look for and access to services that will be used to create the choreography
  - In order to reach this objective a proper service oriented middleware must be defined



MID Research Objectives



MID Contributors' Skills and Expertise

- Main research areas
  - Software Engineering
  - Formal Methods
  - Distributed Systems
  - Context-oriented Programming

- Main research & development activities in these areas
  - Engineering of Service-oriented Systems and Component-based Systems
  - **Automated Synthesis for Composing Distributed Systems (from Protocol Coordination to Protocol Mediation/Adaptation)**
  - Formal Specification and Analysis of Complex Distributed Systems
  - Analysis and Development of Adaptable Context-aware Systems
  - Software behavioral models extraction from black-box software

- Significant Bibliography (a part of)

  - AUTILI M, INVERARDI P, TIVOLI M (2015). *Automated Synthesis of Service Choreographies.* **IEEE SOFTWARE**, Special Issue on "Software Engineering for Internet Computing: Internetware and Beyond", Vol. 32, N. 1, p. 50-57.
  - INVERARDI P, TIVOLI M (2013). *Automatic Synthesis of Modular Connectors via Composition of Protocol Mediation Patterns.* In: Proceedings of the 2013 International Conference on Software Engineering (**ICSE'13**). ISBN: 978-1-4673- 3076-3, url: http://dl.acm.org/citation.cfm?id=2486788.2486790.

Experimentation laboratory of the MID outcomes

- ICSLab: Integration Code Synthesis Laboratory
  - Cloud Infrastructure as a Service (IaaS) for the provision of computational resources and virtual environments for the *deployment* of distributed software systems
  - Cloud Platform as a Service (PaaS) for distributed software systems *simulation & analysis*, and *execution & monitoring*
  - Cloud Software as a Service (SaaS) for the "on-demand" *composition & coordination* of distributed software applications through the *automated synthesis of integration code*

MID Related European Projects

- H2020 European project CHOReVOLUTION - *Automated Synthesis of Dynamic and Secured Choreographies for the Future internet*. Call: *H2020-ICT-2014-1*, Topic: *ICT9 - Tools and Methods for Software Development*, Type of Action: *RIA* **(just started)**
- Global Requested EU Contribution: 3.057.549 €
- The MID1 Principal Investigator is S&T leader

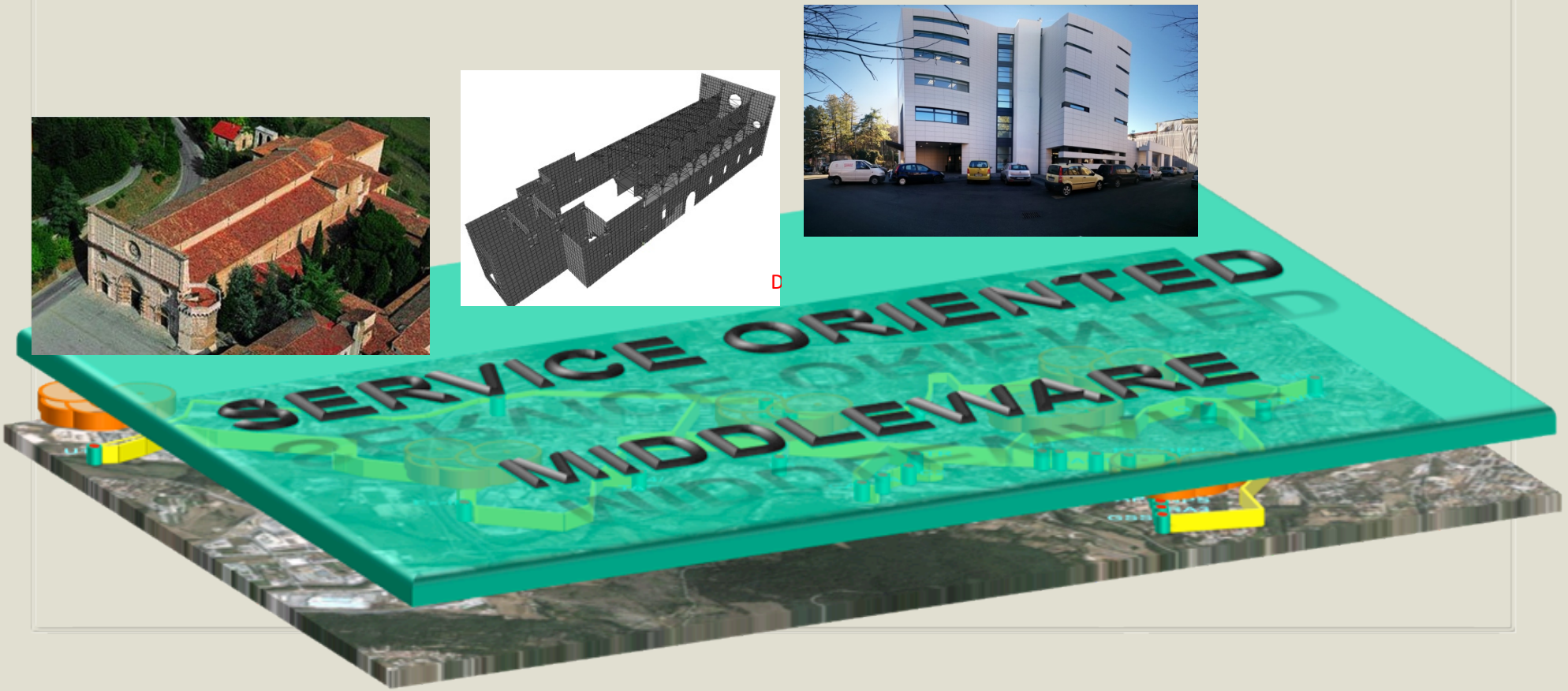
- European FP7 IP project CHOReOS - *Large Scale Choreographies for the Future Internet* **(completed)**
- Global Requested EU Contribution: 6.384.000 €

- European FP7 FET project CONNECT - *Emergent Connectors for Eternal Software Intensive Networked Systems* **(completed)**
- Global Requested EU Contribution: 4.800.000 €

INCIPICT SER work package

SER: Innovative methods and services

- SER1: Structural health monitoring
- SER2: Disaster resilient and energy efficient building automation
- SER3: Cultural Heritage Enhancement



SER1: Structural Health Monitoring, main challenges

(i) to investigate the possible causes of the collapse;

(ii) to monitor the performance of the scaffolding structures and other installed reinforcements (tendons between the walls and temporary composite tape wrapped around the columns for confinement);

(iii) to avoid the progression of damage;

(iv) to explore possible advantages arising from the use of innovative technologies;

(v) to make a long-term analysis of the structure dynamic response and its modification after final retrofitting and reconstruction.

Milestone

Development of a vibrational monitoring system by means of acceleration measurement

Structural analysis by numerical finite element models to spport the structural monitoring design

Installation of the monitoring systems implementation of continuos vibrational monitoring

Modal identification through measurement of the dynamic response due to dfferent loading condition

SER1: Structural Health Monitoring, working plan

- characterization of the dependence of the quantities identified (especially frequencies and damping) from the vibrational amplitude;
- probabilistic and statistical treatment of the measured data and of the results of their processing;
- selection of global indicators for identifying of localized damage;
- network optimization in terms of number and of sensors position;
- improving the reliability of the measures in strongly varying operating conditions, for example in the presence of thermal variations with non-negligible effect;
- integrated design of sensors through by optimal criteria and possibly adaptable in real time;
- solutions of the technical problems regarding the integration of sensors in the new buildings and in the interventions on the existing one;
- design of reconfigurable networks able to maintain their efficiency after an exceptional event adapting their architecture;

The most exciting challenge in the medium to long-term regards the complete integration between monitoring sensors network and monitored structure, until the realization of intelligent systems, equipped with autonomous functions of self-analysis and self-diagnosis, energy self-sufficiency.

SER1: Description

The Structural Health Monitoring (SHM), in the fields of civil engineering, has become an important tool for assess both the vulnerability of the structures and for program the various maintenance actions.

Especially in the zones characterized by high seismicity, as the city of L'Aquila where the monumental building and the cultural heritage constitute an important resource, the monitoring actions play a key role in the decision-making.

The main steps for a complete realization of a Structural Health Monitoring Systems are the following

1. DESING OF THE SYSTEMS
(Targets, choice of sensore, optimal placements)

2. IMPLEMENTATION and SIGNAL ACQUISITION

3. SIGNAL PROCESSING
(the obiective is to extract some important information from acquired data)

STRUCTURAL INTERPRETATION

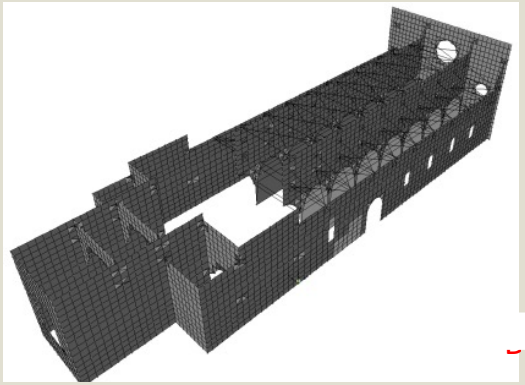
STRUCTURAL HEALTH MONITORING:
Vulnerability and Assessment of the residual life of the structure

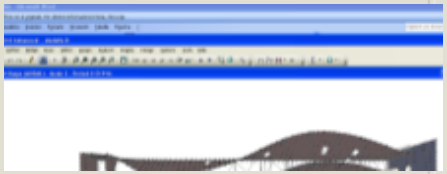
SER1: Laboratory

The Basilica the S. Maria di Collemaggio was heavily damaged in the 2009 L'Aquila Earthquake. The more mportant damage was the total collapse of the transept zone. The SHM had the aim to follow the interaction between the scaffolding system and the structure.

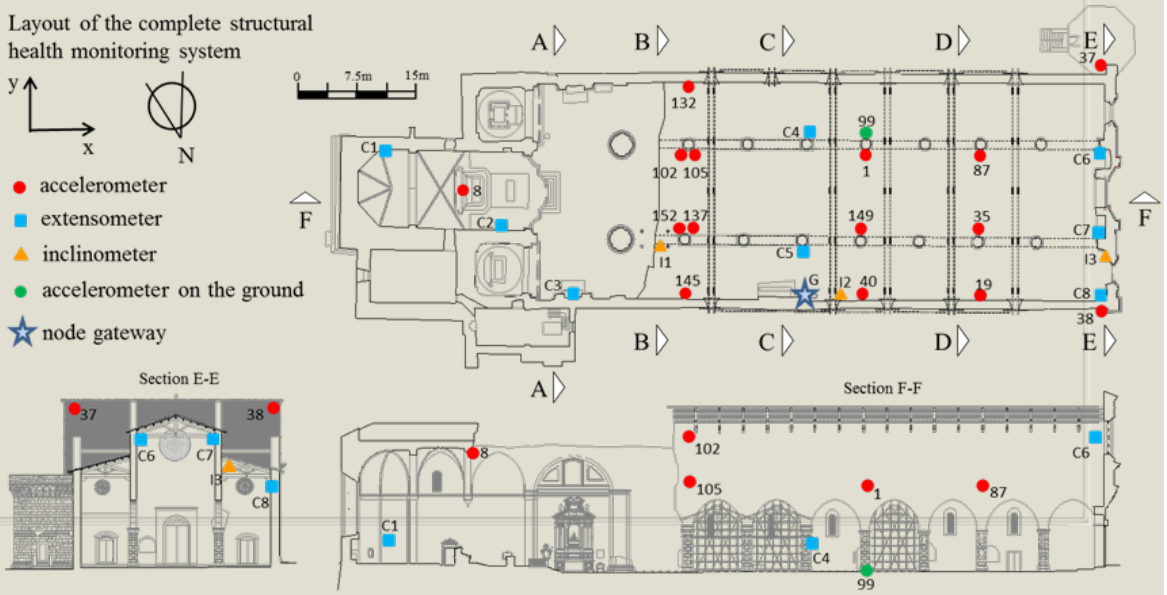
Some numerical model have been implemented to determinate the optimal location of the sensors. Today the system is operational h24 and is composed by 16 accelerometer, 8 extensometer, 3 inclinometer.

Potenza F., Federici F., Lepidi M., Gattulli V., Graziosi F., Colarieti A., "Long term structural monitoring of the damaged Basilica S. Maria di Collemaggio through a low-cost wireless sensor network", Journal of Civil Structural Health Monitoring, in press.





Layout of the complete structural health monitoring system



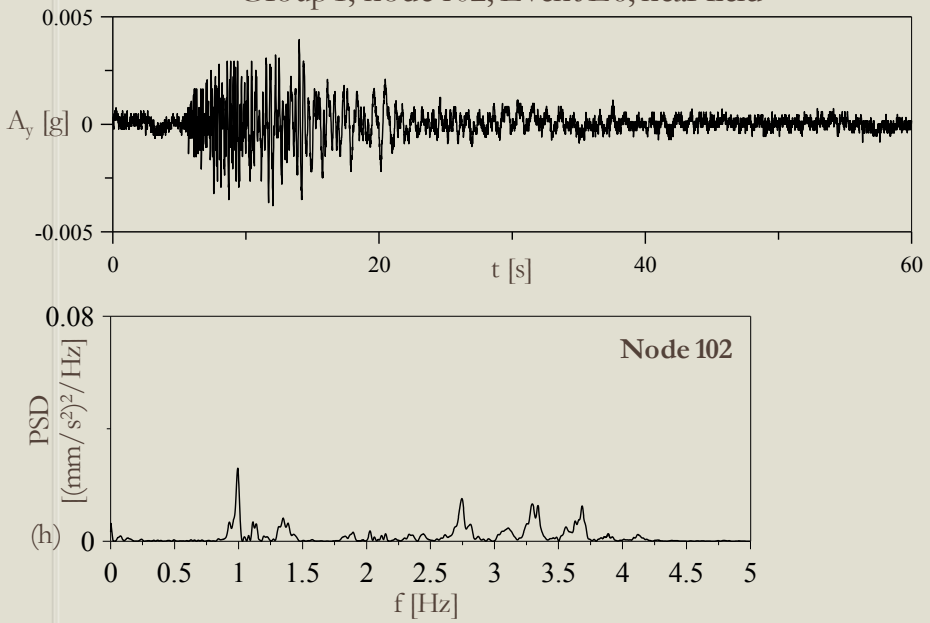
SER1: Data acquisition and signal processing

Main seismic events recorded by the WSN to the Basilica S. Maria di Collemaggio

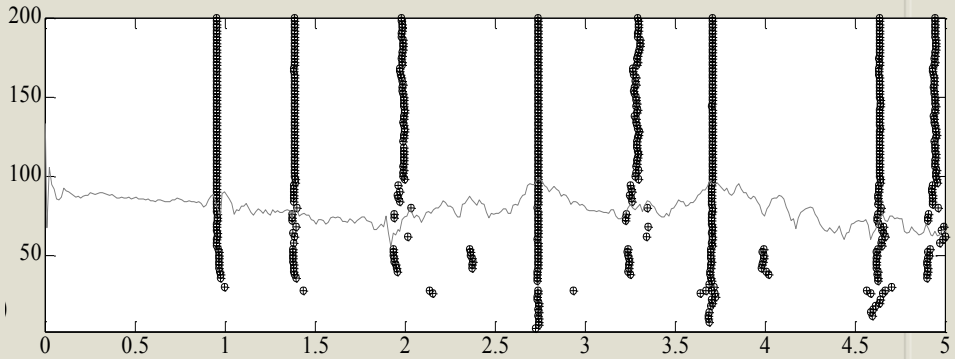
Event	Earthquake/epicenter	D	Date	Time (UTC)	M	PRA [mm/s²]	Group
E1	Main Emilia/Finale Emilia	F	20/05/2012	2:03 AM	5.9	70.4	I
E2	After Emilia/Vigarano	F	20/05/2012	1:18 PM	5.1	17.9	II
E3	After Emila/Cervia-Ravenna	F	06/06/2012	6:08 AM	4.5	10.9	I
E4	L'Aquila/Scoppito	N	14/10/2012	4:32 PM	2.8	71.7	II
E5	L'Aquila/Pizzoli-Scoppito	N	30/10/2012	2:52 AM	3.6	72.7	II
E6	L'Aquila/Pizzoli	N	16/11/2012	3:37 AM	3.2	83.2	I
E7	L'Aquila/Val di Sangro	N	14/02/2014	8:51 PM	2.9	26.2 (60.4)	I
E8	L'Aquila/Valle dell'Aterno	N	04/09/2014	3:55 PM	2.1	18.8	I

D: distance of the epicenter (F=far; N=near); M: magnitude. () relative to the node 37 in global X-direction. PRA: Peak Registration Acceleration

Group I, node 102, Event E6, near field

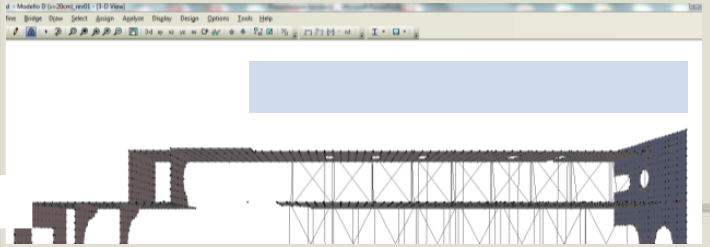


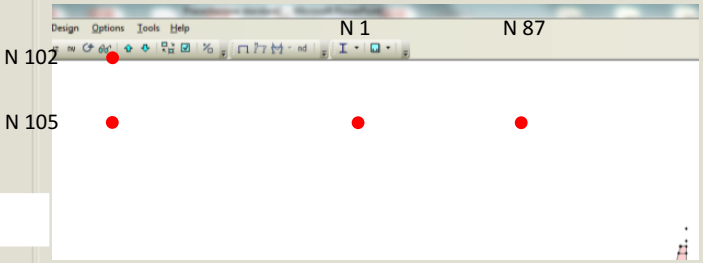
Some signal processing technique are used in the vibration-based. Among them the most important are the Enhanced Frequency Domain Decomposition (EFDD) and the Stochastic Subspace Identification.



Peeters, B., & De Roeck, G. (1999). Reference-based stochastic subspace identification for output-only modal analysis. *Mechanical Systems Signal Processing*, 13(6), 55-878.

SER1: Structural interpretation





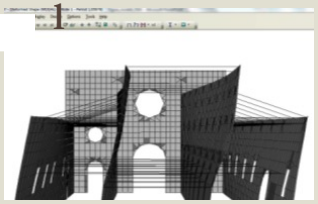
	Frequencies		
Modes	Identified	Numerical	Δ %
1	0.9780	0.9500	2.95
2	1.3970	1.5600	-10.45
3	1.9100	2.0100	-4.98

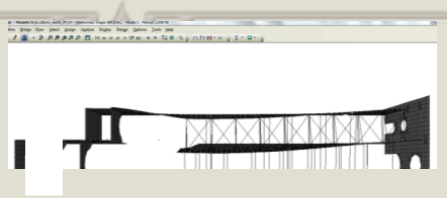
	MAC		
Modes	Reduced		
1	0.9885	0.2081	0.5100
2	0.4118	0.9727	0.0555
3	0.1327	0.0940	0.7840

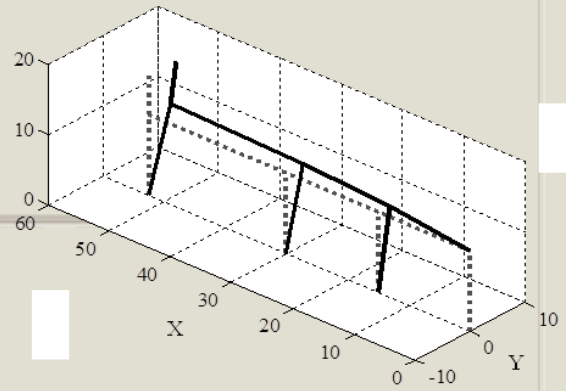
	MAC		
Modes	Expanded		
1	0.9929	0.0078	0.0010
2	0.0079	0.9706	0.0209
3	0.0343	0.0240	0.9447

Numerica | **Identified**

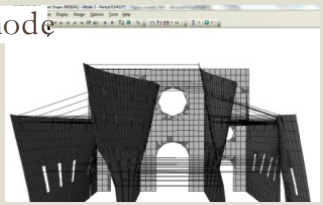
First mode

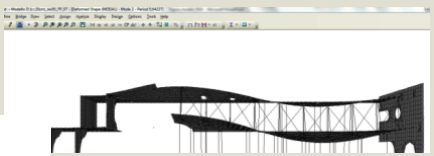


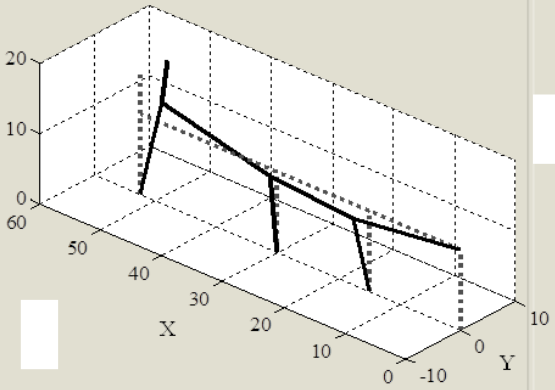




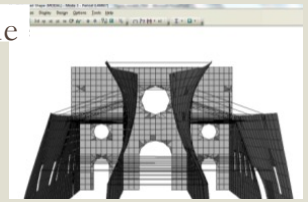
Second mode

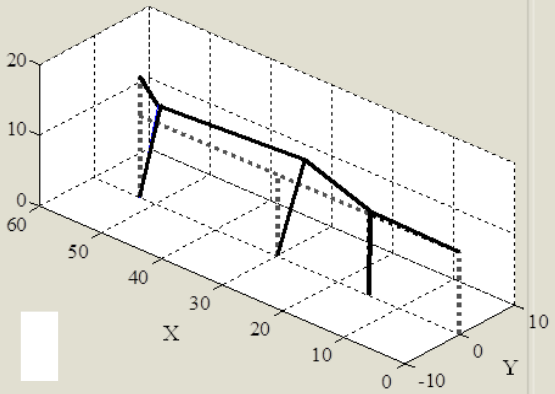






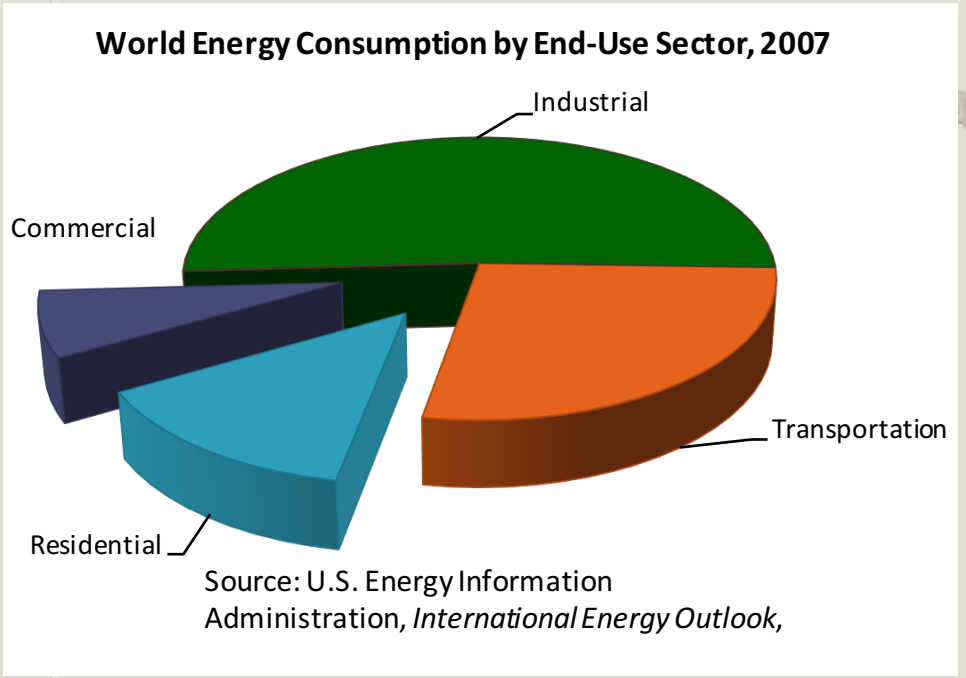
Third mode





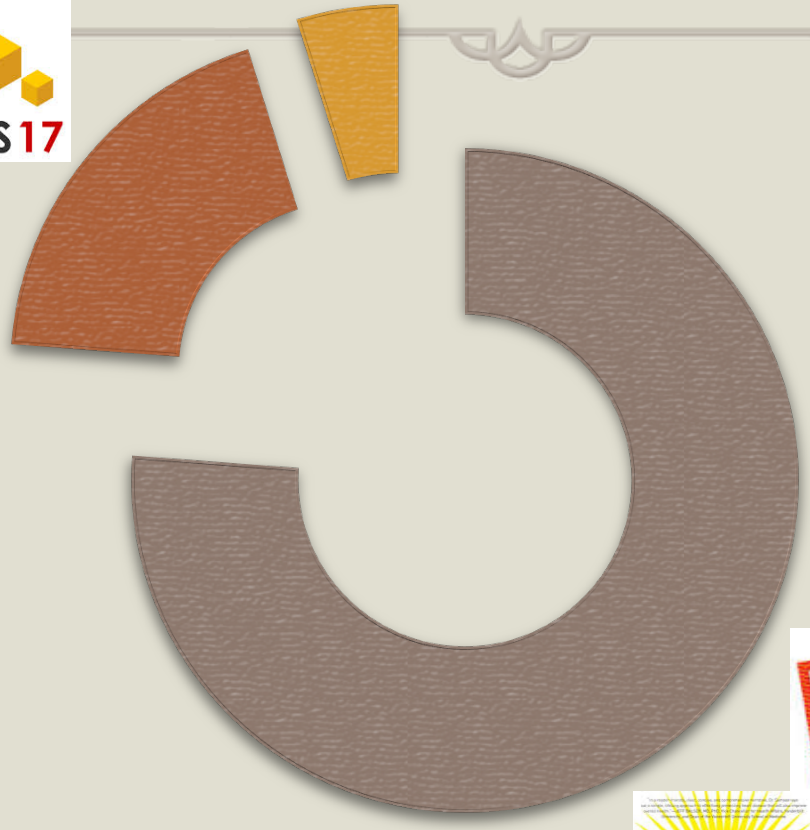
Foti D., Gattulli V., Potenza F., "Output-Only Identification and Model Updating by Dynamic Testing in Unfavorable Conditions of a Seismically Damaged Building", *Computer-Aided Civil and Infrastructure Engineering*, vol. 29, pp. 659-675, 2014.

SER2: Building automation systems: Motivations

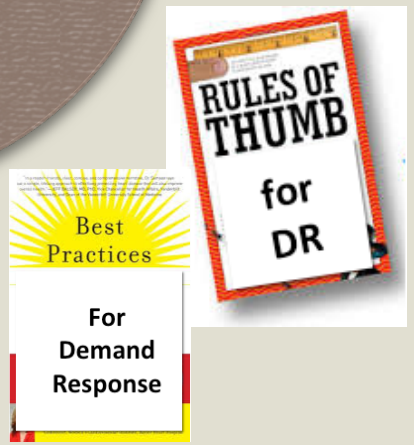


Physical modeling, automatic control, communication: Cyber-Physical Systems

Building automation systems: SoA

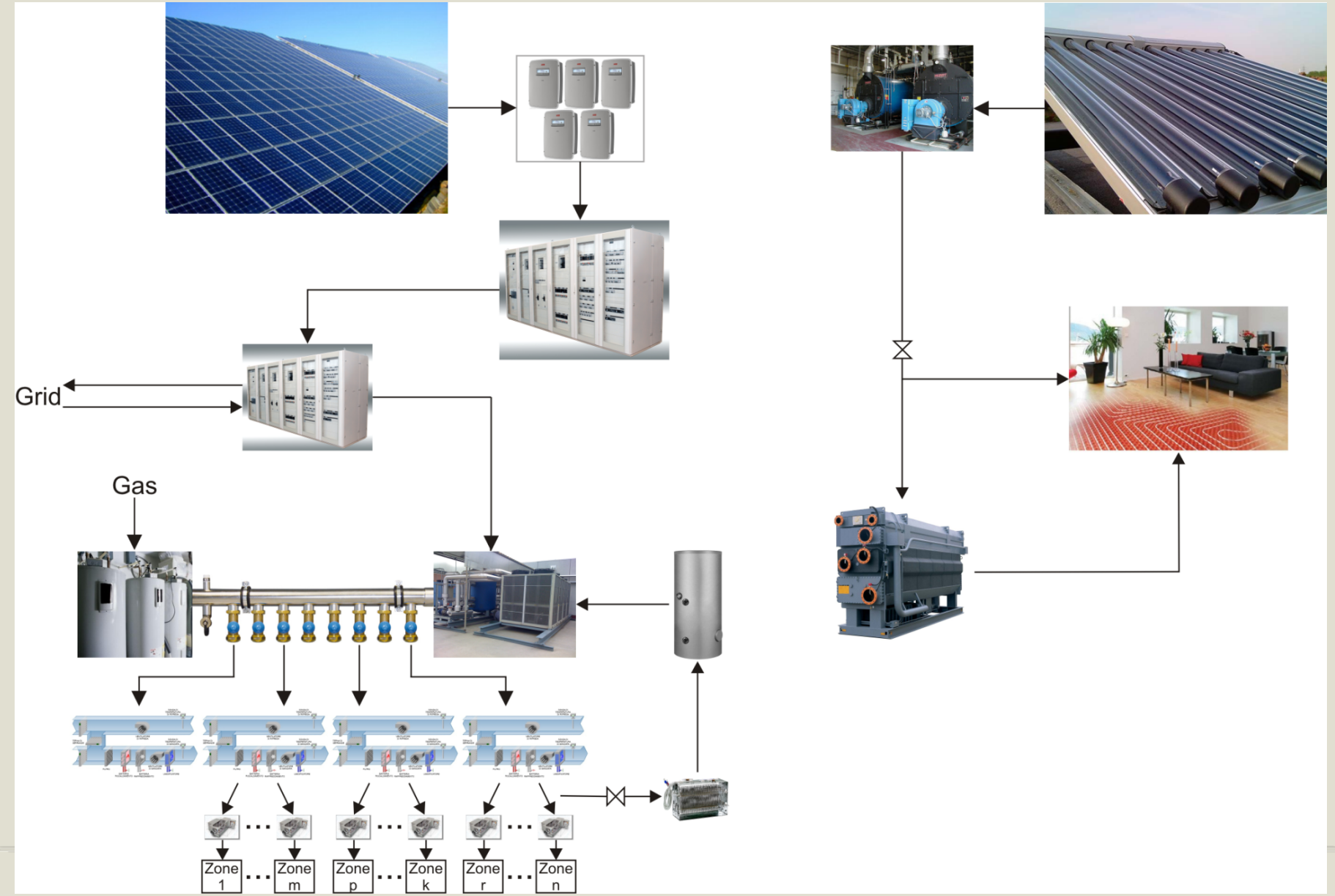


- Rule Based DR
- Model Based DR
- Data-Driven DR



Courtesy of Madhur Behl

Human sciences building in L'Aquila: Currently Rule based cotrol



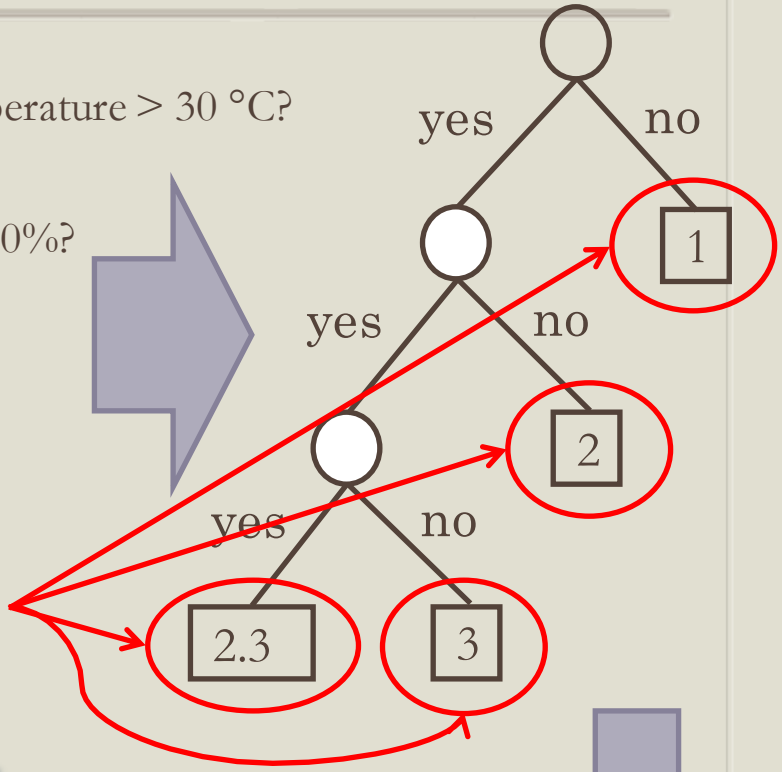
Human sciences building in L'Aquila: Research on Cyber-Physical Systems

DR-Advisor: A Data Driven Demand Response Recommender System.
Madhur Behl, Francesco Smarra, Rahul Mangharam. Applied energy, submitted for publication

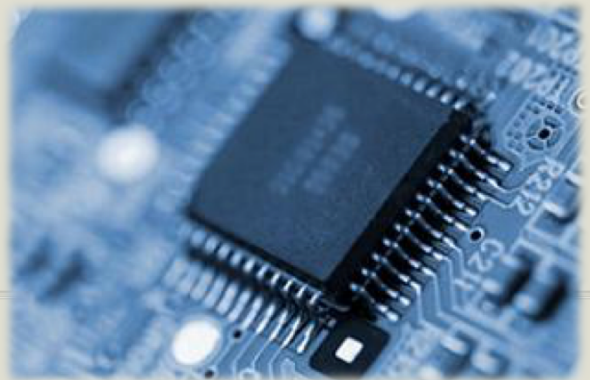
Is outside temperature > 30 °C?

Is humidity < 30%?

Is it cloudy?



POWER CONSUMPTION



Human sciences building in L'Aquila: a living lab

Weather

- Temperature
- Humidity
- Wind Speed
- Wind Direction

Schedule

- Time Of Day
- Day of Week
- Set Points

Building

- Chilled Water Temp
- Lighting Power
- Zone Temperature
- Power Consumption

Web

SER2 Contributors' Skills and Expertise

- Main research areas
  - Control Engineering
  - Distributed Control Systems
  - Data-based Model Identification and Control Systems Design

- Main research & development activities in these areas
  - Regression tree methods for data-based model identification of HVAC systems
  - Formal methods for data-based distributed controller design
  - Co-Design of safe & secure resilient control architectures in SCADA systems

- Significant Bibliography (a part of)

DR-Advisor: A Data Driven Demand Response Recommender System. Madhur Behl, Francesco Smarra, Rahul Mangharam. Applied energy, submitted for publication.

A. D'Innocenzo, F. Smarra, M. D. Di Benedetto. Further results on fault detection and isolation of malicious nodes in Multi-hop Control Networks. 14th European Control Conference (ECC 2015), Linz, Austria, July 15-17, 2015. Best application paper award.

Experimentation laboratory of the SER2 outcomes

- Human Sciences Building & Palazzo Camponeschi Living Labs
  - A virtual lab for data analysis in a real environment of HVAC building automation systems
  - A test-bed for energy efficient optimal control algorithms and inter-building SCADA architectures

SER3 Contributors' Skills and Expertise

- Main research areas
  - Software Engineering
  - 3D scanning & Rendering
  - Interactive graphics and virtual reality

- Main research & development activities in these areas
  - Research and development of 3D modelling techniques accessible via mobile devices
  - Methodologies for customized and contextualized fruition of informative content via mobile devices

- Significant Bibliography (a part of)

  - M. Callieri, P. Cignoni, F. Ganovelli, G. Impoco, C. Montani, P. Pingi, F. Ponchio, R. Scopigno, Visualization and 3D Data Processing in the David Restoration, in: Ieee Computer Graphics and Applications, vol. 24 (2) p. 6. IEEE Press, 2004.
  - M. Callieri, Matteo Dellepiane, Paolo Cignoni, Roberto Scopigno, Processing sampled 3D data: reconstruction and visualization technologies, Digital Imaging for Cultural Heritage Preservation: Analysis, Restoration and Reconstruction of Ancient Artworks, Taylor and Francis, page 105--136 - 2011
  - Roberto Scopigno, Marco Callieri, Paolo Cignoni, Massimiliano Corsini, Matteo Dellepiane, Federico Ponchio, Guido Ranzuglia, 3D models for Cultural Heritage: beyond plain visualization , IEEE Computer, Volume 44, Number 7, page 48-55 - July 2011

Enhancement of cultural heritage through ICT

- Services for the protection, enhancement and enjoyment of the local cultural heritage
  - historical, architectural, artistic and naturalistic
- Stakeholders
  - tourists (end-users)
  - service providers (ISP)
- Visiting a site of interest is enhanced with
  - provision of touristic information in the right way and at the right time using modern localization technology and mobile communications
  - a "cultural social network" of users/tourists
  - information accessed via smartphone or tablet by simply pointing their camera towards the object of interest

Experimentation of SER3 outcomes

First activity:

- Survey and 3D modelling of a barrel vault for "Palazzo Camponeschi" in L'Aquila

SER3-Related European Projects

- "CHRoMOus – Cultural HeRitage MOnitoring Sensors" in the executive program between Italy and Sweden from 2014 to 2017, signed in Stockholm on the 12th of September
- "Vision - Video-oriented UWB based Intelligent Ubiquitous Sensing" FP7 "Ideas" Specific programme ERC Staring Grant 2009, 2010-2015
  - Total cost of the project: 1.173.680 €
  - DEWS cost: 120.342 € - EU contribution: 120.342 €

Conclusions

- L'Aquila as an open/living lab and test bed
- INCIPCT as a platform offering:
  - Support for innovation of the Public Sector
  - Experimental optical ring
  - Provides proper interfaces for applications (Smart City, IoT, etc.), with three pilot activities:
    - Pervasive Structural Health Monitoring (SHM)
    - Pervasive Building Energy management
    - Cultural Heritage promotion through ICT
- First achievement
  - "CHRoMOus – Cultural HeRitage MOnitoring Sensors" in the executive program between Italy and Sweden from 2014 to 2017, signed in Stockholm on the 12th of September 2014