

Embedded Systems & Smart Sensors

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The research group, managed by Alessandra Flammini, includes: Paolo Ferrari, Emiliano Sisinni, Alessandro Depari, Stefano Rinaldi, Francesco Venturini and some Ph.D. students and holders of research grants.

Research activities include:

- **Real-time Communications for smart grids and industry; Clock Synchronization**

Experimental characterization and development of solutions and tools for smart grids (IEC61850) and industrial communications with particular attention to powerline communications and Real-Time Ethernet (RTE). The group developed, in cooperation with Gefran, the first Italian RTE (GDNET). It strictly cooperates with CSMT (Profibus and Profinet Competence Center).



- **Wireless sensor networks for metering and industry**

The group developed patents and proprietary solutions for local companies and, recently, experienced with M-bus for metering and WirelessHART and ISA-100 for industry. Recently, the main research activity has concerned new technologies for multistandard wireless communications (Software Defined Radio) and synchronization.



- **Electronic noses, wearable sensors and smart devices**

The group designed new electronic circuits (ASIC) and instruments for sensor experimental characterization (high-value sensor resistance measurement - from kΩ to over 100GΩ -, small value sensor capacitance -pF-). Attention is now focused on wearable sensors for health and exercises and smart devices for drugs, medicines and nutrition.



Main cooperation with national and international research units



Commission for standards (industrial communications: IEC-65C-MT9, fieldbus and RTE, P. Ferrari; IEC-SC65C-WG16/17, wireless, E. Sisinni; IEC-TC65C, smart grids for ind. Appl, IEEE1588, S. Rinaldi)

Financed Project for more than 1M€

Smart Cities and Communities, Smart Grids, aging, ambient assisted living



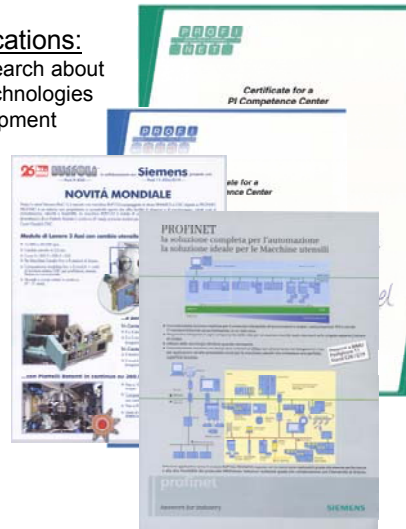
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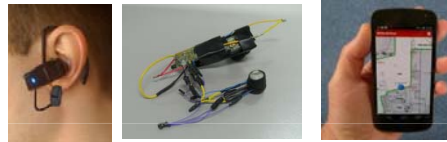


Industrial communications:
competence center, research about synchronization, new technologies and new solution development

Cooperation with C.S.M.T.
www.csmt.it



Wearable sensors and smart devices

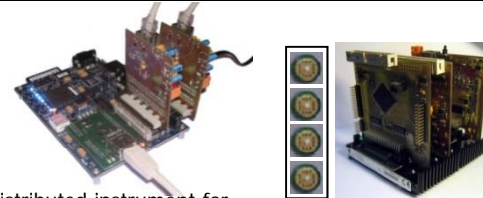


Smart device (indoor) Localization

Biomedical Smart Sensing



Measurement instruments, sensor interfaces



Distributed instrument for Real Time Ethernet and wireless traffic (IEEE802.15.4) analysis

Electronic nose (bread baking aromas)

Synchronization for energy distribution:
IEEE1588 and IEC61850, smart grid



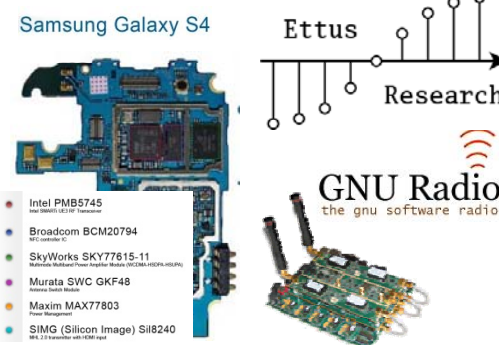
Wireless sensor networks for industry: development of "ad hoc" solutions, active presence in Commissions for emerging standard



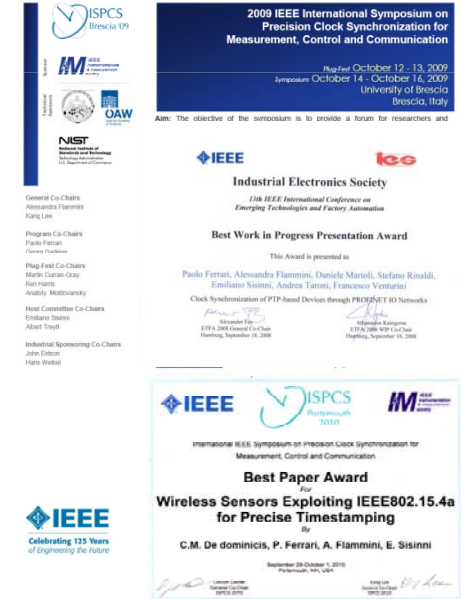
Thermocouple network (128 samples/s)



Wireless Communications: if the number of new technologies is growing up too fast, architectures change (Software Defined Radio, multistandard communications)



Internationalization: cooperation with international research agencies, international conferences, awards



Wireless sensor networks: Italian website for local companies and students (<http://www.ing.unibs.it/~wsnlab/>)



Publications:

• Industrial communications and Wireless sensor networks

Instruments, measurement methods, new architectures and applications for wired and wireless networks, with particular attention to industrial applications and topics concerning timing performance, models, synchronization and coexistence.

- C. M. De Dominicis, P. Privato, P. Ferrari, D. Macii, E. Sisinni, A. Flammini, "Timestamping of IEEE 802.15.4a CSS Signals for Wireless Ranging and Time Synchronization", IEEE Trans. Instrumentation and Measurement, August, 2013, Vol. 62, N. 8, pp. 2286-2296.
- P. Carbone, A. Cazzorla, P. Ferrari, A. Flammini, A. Moschitta, S. Rinaldi, T. Sauter, E. Sisinni, "Low Complexity UWB Radios for Precise Wireless Sensor Network Synchronization", IEEE Trans. Instrumentation and Measurement, September, 2013, Vol. 62, N. 9, pp. 2538-2548.
- A. Bondavalli, F. Brancati, A. Flammini, S. Rinaldi, "Master Failure Detection Protocol in Internal Synchronization Environment", IEEE Trans. Instrumentation and Measurement, Gennaio, 2013, Vol. 62, N. 1, pp. 4-12.
- P. Ferrari, A. Flammini, S. Rinaldi, A. Bondavalli, F. Brancati, "Experimental Characterization of Uncertainty Sources in a Software-Only Synchronization System", IEEE Trans. Instrumentation and Measurement, May, 2012, Vol. 61, N. 5, pp. 1512-1521.
- P. Ferrari, A. Flammini, E. Sisinni, "New Architecture for a Wireless Smart Sensor Based on Software-Defined Radio", IEEE Trans. Instrumentation and Measurement, June, 2011, Vol. 60, N. 6, pp. 2133-2141.
- C. M. De Dominicis, P. Ferrari, A. Flammini, E. Sisinni, "Wireless sensors exploiting IEEE802.15.4a for precise timestamping", 2010 Int. IEEE Symposium on Precision Clock Synchronization for Measurement Control and Communication (ISPCS), Portsmouth (NH), USA, September 27-October 1, 2010, pp. 48-54, ISBN 978-1-4244-5978-0, DOI 10.1109/ISPCS.2010.5609782. **BEST PAPER AWARD**
- P. Ferrari, A. Flammini, S. Rinaldi, E. Sisinni, "On the Seamless Interconnection of IEEE 1588-Based Devices Using a PROFINET IO Infrastructure", IEEE Trans. Industrial Informatics, August, 2010, Vol. 6, N. 3, pp. 381-392.
- P. Ferrari, A. Flammini, D. Marioli, E. Sisinni, S. Rinaldi, (2010) "On the Implementation and Performance Assessment of a WirelessHART Distributed Packet Analyzer", IEEE Trans. Instrumentation and Measurement, May, 2010, Vol. 59, N. 5, pp. 1342-1352, ISSN 0018-9456, DOI 10.1109/TIM.2010.2040907.
- P. Ferrari, A. Flammini, D. Marioli, E. Sisinni, A. Taroni, (2009) "Wired and wireless sensor networks for industrial applications", Microelectronics Journal, September, 2009, Vol. 40, N. 9, pp. 1322-1336, ISSN 0026-2692, DOI 10.1016/j.mejo.2008.08.012.
- A. Flammini, D. Marioli, E. Sisinni, A. Taroni, (2009) "Design and Implementation of a Wireless Fieldbus for Plastic Machineries", IEEE Trans. Industrial Electronics, March, 2009, Vol. 56, N. 3, pp. 747-755, ISSN 0278-0046, DOI 10.1109/TIE.2008.2011602.
- P. Ferrari, A. Flammini, D. Marioli, A. Taroni, (2008) "A Distributed Instrument for Performance Analysis of Real-Time Ethernet Networks", IEEE Trans. Industrial Informatics, February, 2008, Vol. 4, N. 1, pp. 16-25, ISSN 1551-3203, DOI 10.1109/TII.2008.919016.
- A. Depari, A. Flammini, D. Marioli, A. Taroni, (2008) "USB Sensor Network for Industrial Applications", IEEE Trans. Instrumentation and Measurement, July, 2008, Vol. 57, N. 7, pp. 1344-1349, ISSN 0018-9456, DOI 10.1109/TIM.2008.915487.
- A. Ageev, D. Macii, A. Flammini, "Towards an adaptive synchronization policy for wireless sensor networks", IEEE Int. Symp. Prec. Clock Synch. for Meas., Control and Comm. ISPCS 2008., Ann Arbor, MI, USA, September 22-26, 2008, pp. 115-120, ISBN 978-1-4244-2274-6, DOI 10.1109/ISPCS.2008.4659224.
- P. Ferrari, A. Flammini, D. Marioli, E. Sisinni, A. Taroni, (2008) "Coexistence of Wireless Sensor Networks in Factory Automation Scenarios", Sensors & Transducers Journal, April, 2008, Vol. 90, N. 4, pp. 48-60, ISSN 1726-5479.
- A. Flammini, D. Marioli, E. Sisinni, A. Taroni, "Environmental Telemonitoring: A Flexible GSM-DECT-Based Solution", IEEE Trans. Instrumentation and Measurement, October, 2007, Vol. 56, N. 5, pp. 1688-1693, ISSN 0018-9456, DOI 10.1109/TIM.2007.903578.
- P. Ferrari, A. Flammini, D. Marioli, S. Rinaldi, E. Sisinni, A. Taroni, F. Venturini (2008). Clock synchronization of PTP-based devices through PROFINET IO networks. In: Proc. Of ETFA 2008 - IEEE International Conference on Emerging Technologies and Factory Automation. Hamburg Germany, September 15-18, 2008, p. 496-499, ISBN/ISSN: 1-4244-1506-3, doi: 10.1109/ETFA.2008.4638445, **BEST Work-In Progress AWARD**



Publications:

• Communications for energy distribution (Synchronization in substation automation systems, Smart Grids, Smart Meter)

- D. Della Giustina, P. Ferrari, A. Flammini, S. Rinaldi, E. Sisinni, "Automation of Distribution Grids With IEC 61850: A First Approach Using Broadband Power Line Communication", IEEE Trans. Instrumentation and Measurement, September, 2013, Vol. 62, N. 9, pp. 2372-2383.
- P. Ferrari, A. Flammini, S. Rinaldi, G. Prytz, "Mixing Real Time Ethernet traffic on the IEC 61850 Process bus", 2012 9th IEEE International Workshop on Factory Communication Systems (WFCS), Lemgo, Germany, May 21-24, 2012, pp. 153-156.
- A. Flammini, S. Rinaldi, A. Vezzoli, "The sense of time in Open Metering System", 2011 IEEE International Conference on Smart Measurements for Future Grids (SMFG), Bologna, Italy, November 14-16, 2011, pp. 22-27.
- P. Ferrari, A. Flammini, S. Rinaldi, G. Prytz, "Evaluation of Time Gateways for Synchronization of Substation Automation Systems", IEEE Trans. Instrumentation and Measurement, October, 2012, Vol. 61, N. 10, pp. 2612-2621, ISSN 0018-9456, DOI 10.1109/TIM.2012.2199195.
- M. Lixia, A. Benigni, A. Flammini, C. Muscas, F. Ponci, A. Monti, "A Software-Only PTP Synchronization for Power System State Estimation With PMUs", IEEE Trans. Instrumentation and Measurement, May, 2012, Vol. 61, N. 5, pp. 1476-1485.
- C. M. De Dominicis, P. Ferrari, A. Flammini, S. Rinaldi, M. Quarantelli, "On the Use of IEEE 1588 in Existing IEC 61850-Based SASs: Current Behavior and Future Challenges", IEEE Trans. Instrumentation and Measurement, September, 2011, Vol. 60, N. 9, pp. 3070-3081.

• Electronic noses (Electronic circuits and measurement methods for chemical sensors and electronic noses)

- A. Depari, A. Flammini, E. Sisinni, "Measurement of Resistance and Capacitance of MOX Sensors With High Sampling Rate", IEEE Trans. Instrumentation and Measurement, September, 2012, Vol. 61, N. 9, pp. 2483-2491, ISSN 0018-9456, DOI 10.1109/TIM.2012.2192335.
- G. Ferri, A. De Marcellis, C. Di Carlo, V. Stornelli, A. Flammini, A. Depari, J. Nader, (2009) "A single-chip integrated interfacing circuit for wide-range resistive gas sensor arrays", Sensors and Actuators B: Chemical, January, 2009, Vol. 143, N. 1, pp. 218-225, ISSN 0925-4005, DOI 10.1016/j.snb.2009.09.002.
- S. Bicelli, A. Depari, G. Faglia, A. Flammini, A. Fort, M. Mugnaini, A. Ponzoni, V. Vignoli, S. Rocchi, (2009) "Model and Experimental Characterization of the Dynamic Behavior of Low-Power Carbon Monoxide MOX Sensors Operated With Pulsed Temperature Profiles", IEEE Trans. Instrumentation and Measurement, May, 2009, Vol. 58, N. 5, pp. 1324-1332, ISSN 0018-9456, DOI 10.1109/TIM.2009.2012940.
- A. Ponzoni, A. Depari, M. Falasconi, E. Comini, A. Flammini, D. Marioli, A. Taroni, G. Sberveglieri, (2008) "Bread baking aromas detection by low-cost electronic nose", Sensors and Actuators B: Chemical, March, 2008, Vol. 130, N. 1, pp. 100-104, ISSN 0925-4005, DOI 10.1016/j.snb.2007.07.099.

• Wearable sensors and smart devices

- C. M. De Dominicis, A. Depari, A. Flammini, S. Rinaldi, E. Sisinni, A. Vezzoli, "Acquisition and Elaboration of Cardiac Signal in Android Smartphone Devices", 2014 IEEE Sensors Applications Symposium (SAS), Queenstown, New Zealand, February 18-20, 2014, in press.
- L. Berghella, A. Depari, P. Ferrari, A. Flammini, S. Rinaldi, E. Sisinni, "Low-power wireless interface for smart metering handheld devices", 2014 IEEE Sensors Applications Symposium (SAS), Queenstown, New Zealand, February 18-20, 2014, in press.
- C.M. De Dominicis, A. Depari, A. Flammini, S. Rinaldi, A. Vezzoli, "Multi-sensor system with Bluetooth connectivity for non-invasive measurements of human body physical parameters", Sensors and Actuators A: Physical, November, 2013, Vol. 202, pp. 147-154.
- C. M. De Dominicis, A. Depari, A. Flammini, S. Rinaldi, E. Sisinni, "Smartphone based localization solution for construction site management", 2013 IEEE Sensors Applications Symposium (SAS), Galveston, TX, USA, February 19-21, 2013, pp. 43-48.
- C. M. De Dominicis, D. Mazzotti, M. Piccinelli, S. Rinaldi, A. Vezzoli, A. Depari, "Evaluation of Bluetooth Hands-Free profile for sensors applications in smartphone platforms", 2012 IEEE Sensors Applications Symposium (SAS), Brescia, Italy, February 7-9, 2012, pp. 120-125.

