

# Architecture of the Monitoring System designed for an Active Guard Rail

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**Abstract** – This paper describes the architecture of a monitoring system developed for a Wireless Active Guardrail System (WAGS). A WAGS is a Wireless Sensor Network (WSN) embedded on guardrails along the road infrastructure. The proposed WAGS architecture consists of four levels: *Road, Concentrator, Storage and Monitoring*. In this paper, an architecture overview of the proposed WAGS is carried out. Furthermore, a wide description of the last three levels is reported. At the road level, the measurements are performed by sensor nodes. Instead, at the *Concentrator level*, the *Concentrator* configures each sensor node and collects the measured values. The storage and the presentation of all the measurements have been realized through a multilayer server infrastructure written in Java language. In order to verify the communication protocol and the node configuration, several experimental tests have been performed and the obtained results reported.

## I. INTRODUCTION

The main target of a guardrail is to avoid that vehicles go off road. An interesting application is to embed sensors and wireless communication technologies on guardrails. In this way, the guardrail becomes an active system, which can provide information about the road infrastructure. An intelligent system for active protection mounted on guardrails has been designed in the project called “Barriera Attiva” - active guardrail [1]. The “Barriera Attiva” objective is the design and realization of an innovative guardrail based on a new concept of road safety. “Barriera Attiva” adds active functionalities to the guardrail. The active functionalities consist of a distributed measurement system for crash prevention and environmental monitoring along the road infrastructure. These functionalities are realized through an innovative Wireless Sensor Network (WSN) placed on the guardrail for monitoring the road infrastructure and for providing safety warnings to drivers. The architecture layers of the proposed WAGS are shown in Fig.1. The first layer, called Road Level, consists of a distributed measurement system, embedding two WSN node typologies: traffic safety node [3] and environmental node [4]. These nodes provide to the monitoring system and to the drivers, information about the road infrastructure

by measuring the following physical quantities:

- vehicle-guardrail distance and impact, and vehicle speed, measured by the traffic safety WSN node;
- Carbon Monoxide (CO), Nitrogen Dioxide (NO<sub>2</sub>), Sulfur Dioxide (SO<sub>2</sub>) concentrations, ambient temperature and relative humidity, measured by the environmental WSN node.

Each node has an IPv6 [5] address and runs a real time operating system, TinyOS [6]. The communication between nodes is based on a mesh network, as described in [7]. The 6LoWPAN standard [8] implements the transmission of the IPv6 over the IEEE 802.15.4 [9, 10]. The second layer, called *Concentrator level*, performs the following activities: (i) storage of the measurements provided by the nodes, (ii) configuration of each WSN node, and (iii) transmission of commands to the nodes.

In order to realize these activities, a communication protocol and two software systems have been developed. The former is placed on each WSN node and it is written in nesC language. The latter is placed on a Raspberry Pi and consists of an UDP server listening on a IPv6 socket, written in C language. The measurements are periodically sent from the *Road Level* to the *Concentrator Level*. By using a web service, the measured values are sent to a server infrastructure placed on the *Storage and Presentation Level* through Internet. This server infrastructure is called *Service Center*. The *Service Center* stores the data in a database and the *Monitoring Level* shows them to the user through several media supports.

The aim of this paper is to describe the software and the hardware of *Concentrator, Storage and Presentation, and Monitoring levels*. Furthermore, in order to verify the communication protocol and the node configuration, several experimental tests have been performed. The structure of the paper is organized as it follows. In Section II, the hardware and software descriptions of each *Concentrator level* node and the communication protocol are presented. Section III describes the *Service Center*. The results obtained from an experimental validation of the protocol are reported in Section IV. Last section concludes the paper.

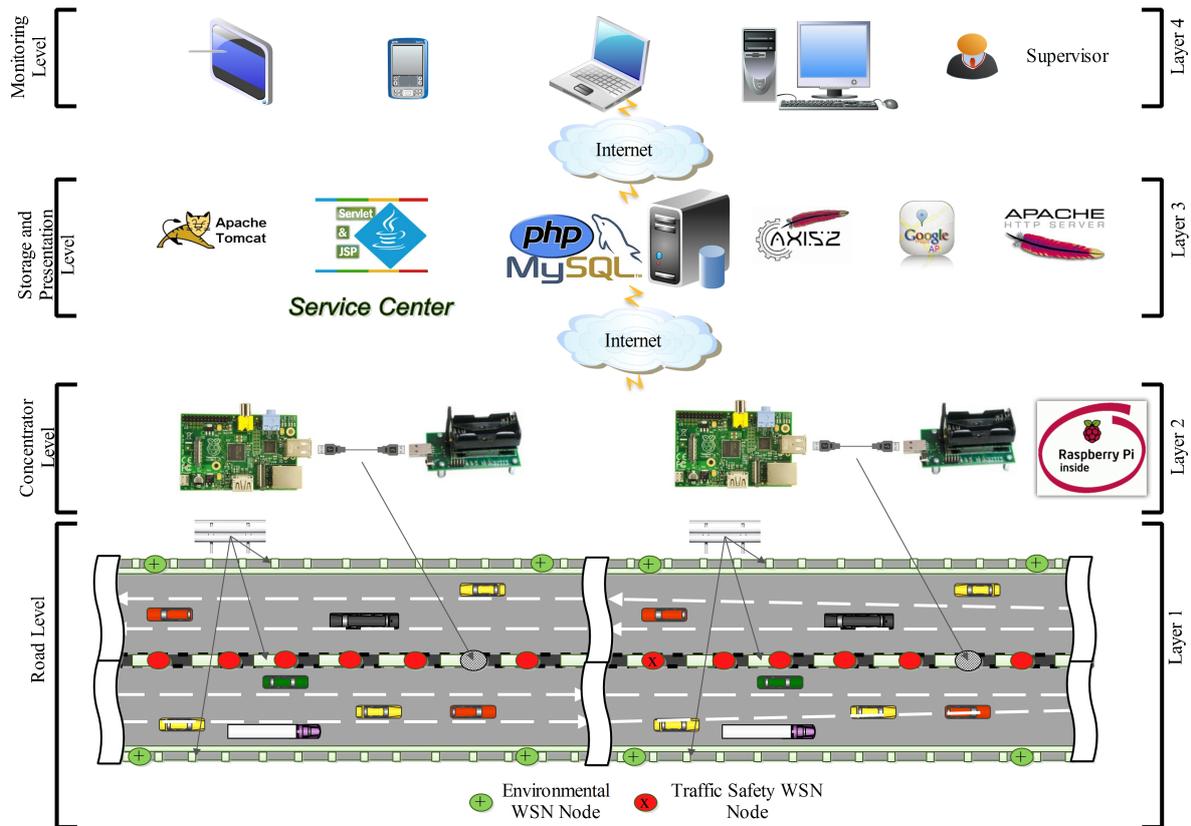


Fig. 1. Architecture layers of "Barriera Attiva".

## II. CONCENTRATOR LEVEL

### A. Hardware

The *Concentrator Level* consists of a Raspberry Pi [11] connected to an IRIS node via USB [7], (see Fig.2). The Raspberry Pi, is a low cost single board computer (SBC) embedded hardware based on the Broadcom 2835 system on chip (SoC), including the 700 MHz ARM1176JZF CPU and the Broadcom 250 MHz VideoCore IV GPU with a RAM of 512 MB. The system boots from the SD card where the Debian-derived Raspbian [12] is installed.

### B. Software

In Fig.3, the interaction between the WSN Node and the *Concentrator* is depicted.

The aims of the *Concentrator Level* are: (i) to configure the WSN Nodes and (ii) to store the measurements obtained from the Road Level. In order to comply those purposes, a distributed software for the *Concentrator* (IP Base Station Application) and for each WSN node has been developed. The IP Base Station Application allows to receive all the configurations and periodic data packets sent by the nodes. It runs on the Raspberry Pi and consists of two software processes:

- a routing driver, listening on the usb port, that

forwards the 6LoWPAN packet from and to the WSN nodes;

- an UDP server listening on a IPv6 socket bound to the 7001 port in order to communicate with the WSN node via the routing driver.

When the WSN node boots, it sends a configuration packet request to the *Concentrator* for retrieving its configuration. Once the configuration is retrieved, the WSN node starts to make measurements. In case of speed and environmental measurements, the node sends the measured values to the *Concentrator*.

### C. Communication protocol

The packets exchanged between WSN nodes and the *Concentrator* can be divided in two typologies depending

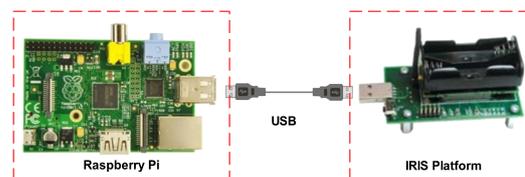


Fig. 2. The Concentrator Level hardware.

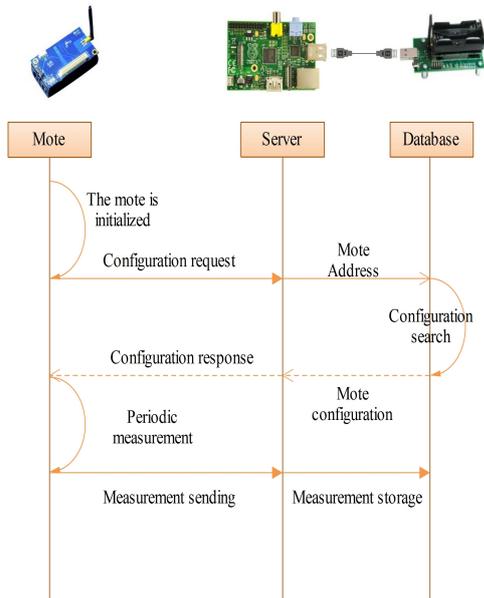


Fig. 3. The Concentrator Level sequence diagram.

on the measurement and the packet priority. For example the transmission of the impact event has a higher priority than the sending of periodic data required by speed and environmental measurements. In Fig.4, the packet structure of the message is reported. It contains three fields:

- the header section, consisting of four bytes to discriminate a configuration packet from a periodic data, to fix the priority of the packet and to distinguish

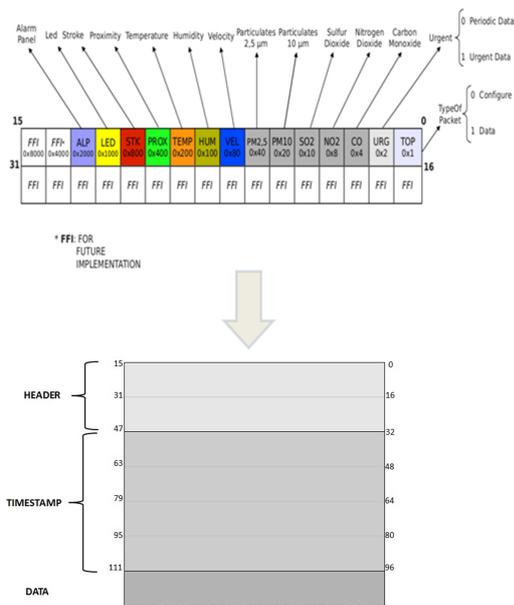


Fig. 4. Protocol structure.

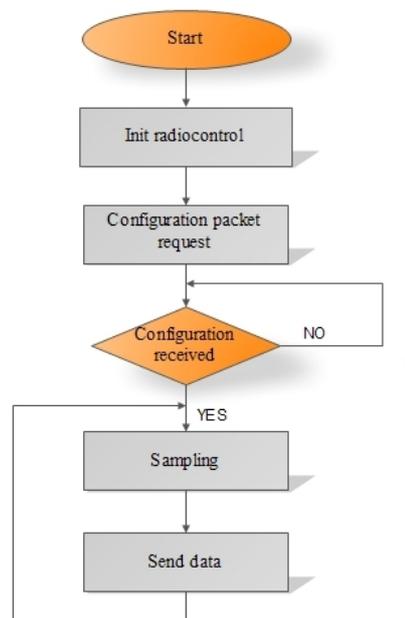


Fig. 5. The flow chart for the sensor software.

the measurement typology;

- the timestamp section, consisting of eight bytes;
- the data payload, which has dynamic dimension depending on the measurement.

The first bit of the header section is the TOP (Type of Packet), if it is set to 1 the packet is a data packet instead if it is set to 0 it is a configuration packet. The second bit is the URG (Urgent), if it is set to 1 the data packet is a periodic one instead if it is set to 0 it is an urgent one (e.g. the impact event). The third bit and the other fourteen bits represent the device measure bits.

#### D. WSN node: software

The WSN node firmware is written in the nesC language and is based on the TinyOS operating system. The type of WSN node is configured by setting the device measure bit. In order to receive the configuration, an UDP server listening on the 7001 port has been implemented on the node. In Fig.5, the flow chart of the software for each WSN node is shown.

When the WSN node boots, the radio on the chip is initialized and the node sends a configuration packet. This packet has: a TOP bit set to 0, URG set to 0 and the device measure bits set according to the node measurements. Once the configuration packet is sent, the WSN node is listening on the UDP server waiting for the configuration packet. When the configuration packet is received, the WSN node sets the periodic time to send the data, acquires the measurements and, if requested, sends them to the Concentrator, reachable through its IPv6 address.

### E. Concentrator: software

On the *Concentrator*, a 6LoWPAN driver has been developed. This driver waits to receive on the USB the packets and forwards them to an UDP server. The UDP server, written in C language, is listening on an IPv6 socket bound to the 7001 port. The server accesses a database to retrieve WSN node configuration and stores the measured values. In Fig.6, the flow chart of the *Concentrator* software is depicted.

When the Raspberry Pi boots, the UDP server is automatically started and listens on an IPv6 non-blocking socket. The concurrency is regulated using a select system call [13], bound to the 7001 port. All the packets received from the WSN are inspected in the header section. According to the TOP value, the packet is recognized as *Configuration* or *Data type*. If the packet received is a configuration, the server starts a query on the database to find the node configuration.

The query is based on the WSN node IPv6 address and on the device measure bits present in the packet header section. If the node is found according to its IPv6 address, its settings are retrieved. Otherwise, if the node is not found, the default settings are retrieved and a row is added in the database with the node settings. If the received packet contains data, the measures encapsulated in the packet are stored in a local database, according to the device measure bits.

### III. SERVICE CENTER

The interface of the *Service Center* allows to monitor the data received from the *Concentrator Level*. As

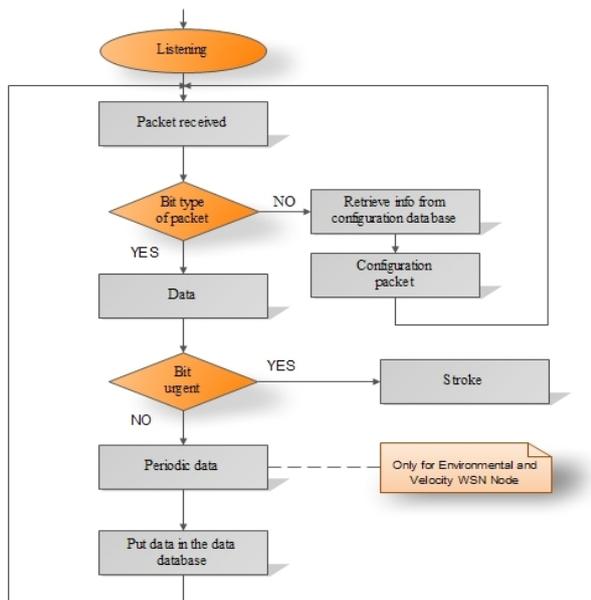


Fig. 6. The flow chart for the *Concentrator* software.

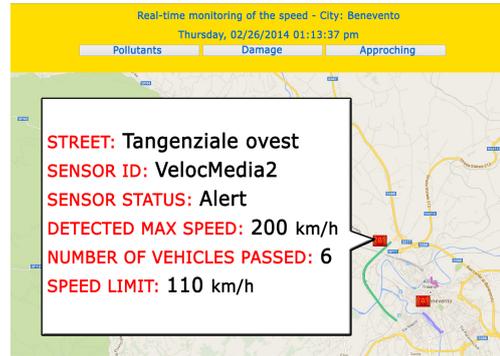


Fig. 7. Visualization of the data acquired by a speed sensor.

already said, the measured quantities are environmental parameters, speed and number of transit vehicles and impact events. In order to show these measured quantities on a map, the Google Maps Geolocation API [14] has been used (see Fig.7). By clicking on a map point corresponding to a street section, it is possible to see the sensors ID, the sensors status and the measured quantities. The *Service Center* is based on a multi-layer structure, as depicted in Fig.8. It consists of *Data Layer* and *Presentation Layer*, for implementing the storage and presentation functionalities respectively.

#### A. Data Layer

The *Data Layer* is based on a multi-tier architecture in which one tier is represented by the web service, used to transport data from and to *Concentrator Level*. The second tier is represented by a database system. The web service tier is implemented using the Apache Axis2 module [15]. The database tier, implemented using a MySQL DBMS [16], stores the data received from the *Concentrator Level* through web service tier and it makes them available to the *Presentation Layer*. The *Presentation*

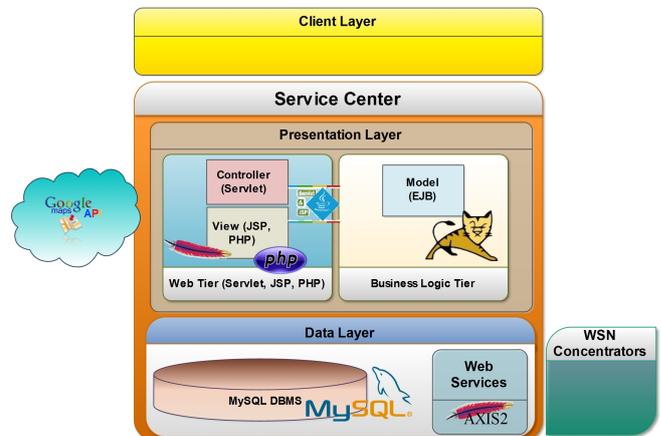


Fig. 8. Data and presentation layer.

Layer is based on J2EE [17] technology and consists of two tiers: the “Web Tier” and “Business Logic Tier”. They implement the Model-View-Controller (MVC) [18] architectural pattern.

### B. Presentation layer

When an user logs on the Service Center, through a web browser, jsp pages show the measured data from the sensors and the sensors status. The jsp page request is processed by the servlet and the data are encapsulated and transported through JavaBeans [19]. It follows a brief description of each *Presentation tier*. The Web Tier was developed through a Web Server Apache Tomcat [20] and contains, referring to the already mentioned MVC pattern, the following software components:

- View: jsp pages that allow the presentation of the data stored on the *Data layer* on cartographic maps using Google Maps Geolocation API. Php pages used for the configuration of the *Service Center* and the access to the configuration data via a MySQL connector.
- Controller: the java servlet is involved in the sorting of the data traffic between the *Presentation Layer* and the *Data Layer* through the Business Logic Tier.

The Business Logic Tier was developed through a Tomcat Application Server and, referring to the MVC pattern, contains the Model implemented by JavaBeans components.

## IV. PROTOCOL VALIDATION

In order to validate the software developed on the nodes and *Concentrator*, a benchmark scenario has been designed, as shown in Fig.9.

The experimental setup consists of three WSN nodes placed at a mutual distance of 4 m. The distance between each node and the *Concentrator* is of 8 m. Furthermore, the *Concentrator* communicates with a computer via

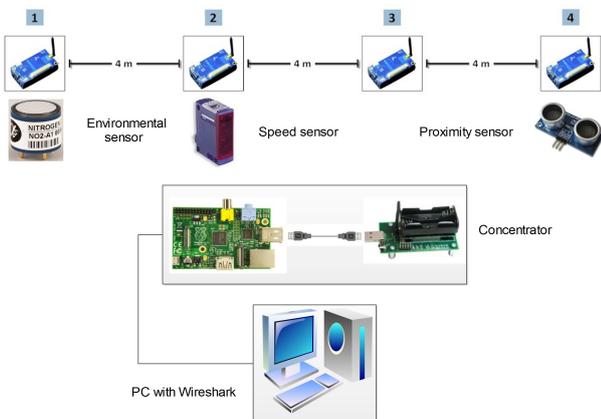


Fig. 9. Test setup.

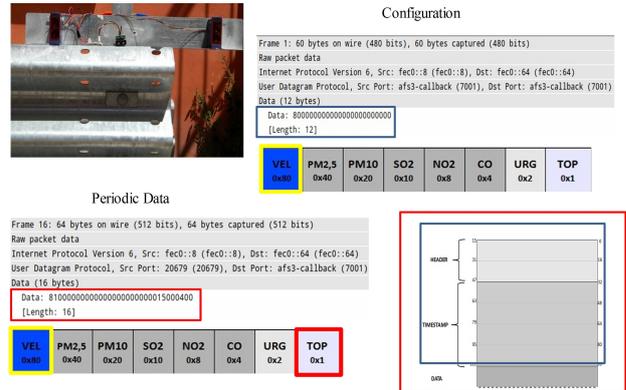


Fig. 10. Speed WSN node Wireshark capture.

ethernet. The first WSN node is an environmental sensor that measures SO<sub>2</sub>, NO<sub>2</sub>, CO. The second one is a speed sensor that measures medium speed and the third one consists of a proximity sensor. The first two WSN nodes send and receive both configuration packets and data packets, while the third one requires only the configuration packet. By using the TCPdump tool [21], the packet sent and received from the *Concentrator* is stored on a logging file on the Raspberry Pi SD card. TCPdump is a command line tool that provides to the PC the logging file, via ethernet. By using the Wireshark tool [22], the contents of this file are shown to the user.

In Fig.10, the experimental test results for the speed sensor are reported. As it is possible to see in the Configuration packet, the TOP bit is set to 0 and the VEL bit is set to 1 as expected. In the Periodic Data packet, TOP bit is set to 1 and the data section contains the average value of the vehicle speeds.

The same results was obtained for the environmental sensor, as shown in Fig.11. As it is possible to see in the Configuration packet, the TOP bit is set to 0 and the SO<sub>2</sub>,

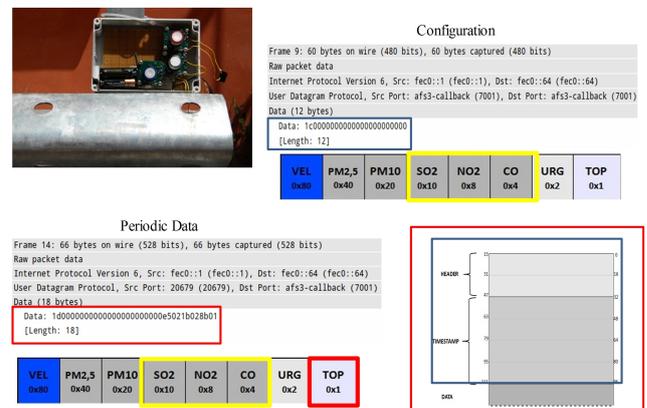


Fig. 11. Environmental WSN node Wireshark capture.

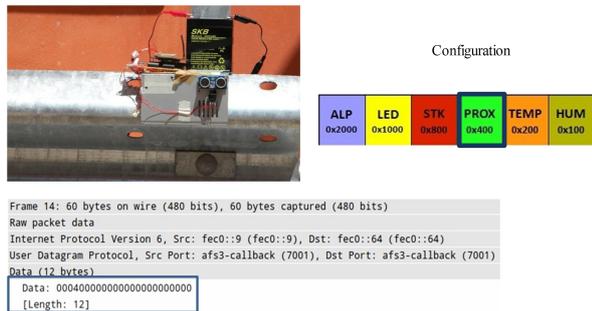


Fig. 12. Proximity WSN node Wireshark capture.

NO<sub>2</sub>, CO bits are set to 1 as expected. In the Periodic Data packet, the TOP bit is set to 1 and the data section contains the SO<sub>2</sub>, NO<sub>2</sub>, CO values.

Fig.12 depicts the test results for the proximity sensor. As it is possible to see in the Configuration packet, the TOP bit is set to 0 and the PROX bit is set to 1 as expected. The data periodic packet is not sent. The reported results comply with the expected behaviour of the protocol.

## V. CONCLUSIONS

In this paper the architecture overview of a WAGS was presented. Furthermore, the hardware and software of each WSN node and the communication protocol were described. A description of the *Service Center* that implements the user interface was reported. In order to validate the protocol and the software, experimental tests were performed. Three scenarios were investigated, using a speed, an environmental, and a proximity WSN nodes. All the test results comply with the expected protocol behaviour.

## ACKNOWLEDGMENT

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## REFERENCES

- [1] Project PON01\_03100, “Barriera Attiva”. Available:<http://www.barrieraattiva.unisannio.it>.
- [2] P.Daponte, L.De Vito, F.Picariello, S.Rapuano and

I.Tudosa, “Wireless sensor network for traffic safety”. Proc. of IEEE Workshop on Environmental, Energy, and Structural Monitoring Systems, Perugia, Italy, 28 Sept. 2012, pp. 42-49.

- [3] P.Daponte, L.De Vito, S.Rapuano and I.Tudosa, “Wireless active guardrail system for traffic safety: preliminary tests of speed and proximity measurement”. Proc. of Int. Instr. and Measurement Technology Conference (I2MTC). Minneapolis, 6-9 May 2013, pp. 737-742.
- [4] L.De Vito, V.Cocca, M.Riccio and I.Tudosa, “Wireless active guardrail system for environmental measurements”. Proc. of IEEE Workshop on Environmental, Energy, and Structural Monitoring Systems, Perugia, Italy, 28 Sept. 2012, pp. 50-57.
- [5] Internet Protocol, Version 6 (IPv6) Specification. Available:<http://tools.ietf.org/html/rfc2460>.
- [6] TinyOS. Available:<http://www.tinyos.net>.
- [7] IRIS mote. Available:<http://www.memsic.com>.
- [8] 6LoWPAN standard. Available: <http://www.cs.berkeley.edu/~jwhui/6lowpan.html>.
- [9] P.Daponte, L.De Vito, F.Picariello, S.Rapuano, I.Tudosa, “Prototype design and experimental evaluation of wireless measurement nodes for road safety”, Measurement, vol. 57, Nov. 2014, pp.1-14.
- [10] P.Daponte, L.De Vito, G.Mazzilli, S.Rapuano and I.Tudosa, “Network Design and Characterization of a Wireless Active Guardrail System”. Montevideo, Uruguay, 12 May 2014.
- [11] The Raspberry Pi. Available: <http://www.raspberrypi.org/>.
- [12] The rapsbian os. Available:<http://www.raspbian.org/>.
- [13] The man for the C system call select. Available:<http://www.unix.com/man-page/freebsd/2/select/>.
- [14] The Google Maps Geolocation API. Available: <http://developers.google.com/>.
- [15] The Apache Axis module. Available: <http://ws.apache.org/axis/>.
- [16] The MySQL server. Available: <http://www.mysql.com/>.
- [17] The Java 2 Enterprise Edition. Available: <http://java.sun.com/j2ee>.
- [18] The Model View Controller Pattern. Available: <http://en.wikipedia.org/wiki/Model-View-Controller>.
- [19] The Enterprise JavaBeans. Available: <http://java.sun.com/products/ejb/docs.html>.
- [20] The Apache Tomcat module. Available: <http://jakarta.apache.org/tomcat/>.
- [21] The TCPdump sniffing tool. Available:<http://www.tcpdump.org/>.
- [22] The Wireshark sniffing tool. Available:<http://www.wireshark.org/>.

## Index of Authors

### A

Abakumov, Gleb A. ....	554
Abate, Francesco .....	1106
Adamo, Francesco .....	620
Affanni, Antonio .....	807
Aggravi, Marco .....	798
Agrež, Dušan .....	844
Akyel, Cevdet .....	1086
Alesini, David .....	80
Aminian, Kamiar .....	765
Amoroso, Sara .....	200
Anagnostopoulos, Ioannis .....	726
Anania, Maria Pia .....	69, 75
Andria, Gregorio .....	626
Andriukaitis, Darius .....	305
Andrysiewicz, Wojciech .....	341
Andò, Bruno .....	794
Anghel, Albert-Ciprian .....	775
Anghel, Mirela .....	647
Anghel, Mirela-Adelaida .....	775
Angrisani, Leopoldo .....	534, 661, 1116
Arab, Homa .....	1086
Arapova, Alla V. ....	554
Arpaia, Pasquale . 242, 359, 381, 822, 839, 910, 915, 920, 1057, 1068	
Asada, Kunihiro .....	812
Attivissimo, Filippo .....	620
Ausanio, Giovanni .....	50
Ausilio, Ernesto .....	60
Avizzano, Carlo Alberto .....	1

### B

Baccigalupi, Aldo .....	1080
Baccigalupi, Carlo .....	242, 381
Baglio, Salvatore .....	794
Balato, Marco .....	1005
Bandini, Valeria .....	221
Barabucci, Gioele .....	743
Barberis, F. ....	320
Barra, Francesco .....	1005
Battaglini, Luigi .....	1122
Battista, Luigi .....	315
Baumgartner, Bernhard .....	183, 272
Beaumont, Anthony .....	816
Bednář, Pavel .....	942
Belega, Daniel .....	709
Bellaveglia, Marco .....	69
Belleveglia, Marco .....	75
Ben Mnaouer, Adel .....	450
Ben Rhouma, Ons .....	483
Ben-Romdhane, Manel .....	336, 353
Bergamasco, Massimo .....	1
Bernasconi, Giancarlo .....	987

Bersan, Silvia .....	216
Bestetti, Massimiliano .....	987
Biancacci, Nicolò .....	80
Bifulco, Paolo .....	602, 606, 610, 780, 786, 790, 856
Bilbao de Mendizabal, Javier .....	144
Biondi, Giovanni .....	221, 226
Blanc, Isabelle .....	35
Bogonez-Franco, Paco .....	895
Boine-Frankenheim, Oliver .....	139
Bologna, Mauro .....	597
Bonavolontà, Francesco .....	1101
Bongioanni, Paolo .....	862
Bongiorno, Jacopo .....	953, 964
Bourke, Alan K. ....	765
Bouvet, Pierre-Jean .....	164
Boyer, Daniel .....	1041
Brando, Mirko .....	40
Braun, H. ....	827
Breñosa, Jose .....	439
Briante, Riccardo .....	1063
Brofferio, Sergio .....	987
Brunetti, Luciano .....	1074
Bruno, Antonio .....	626
Brzyski, Rafał .....	754
Bubnov, Michail P. ....	554
Bucci, Giovanni .....	455, 548
Buglione, Luigi .....	737
Buhagiar, K. ....	904
Burrascano, Pietro .....	1122
Butcher, Mark .....	445
Buzinny, Michael .....	289
Buzio, Marco .....	816, 827, 904, 910, 915, 920

### C

Caciotta, Maurizio .....	396, 402, 558
Cagnetti, Marco .....	563
Caiazza, Domenico .....	822
Cairo, Roberto .....	122
Caldara, Salvatore .....	976
Caliandro, Rocco .....	299
Caliano, Giuseppe .....	1127
Caligiuri, Luigi Maxmilian .....	174, 518
Callegaro, Luca .....	97, 1074
Campanella, Carlo Edoardo .....	412
Candiani, Alessandro .....	311
Canet, Pierre .....	1036
Cangemi, G. ....	489
Cannazza, Giuseppe .....	507
Capra, Pier Paolo .....	932
Capriglione, Domenico .....	265, 523, 1116
Caramazza, Cesare .....	40
Carbone, Paolo .....	665
Carbonell-Ventura, Montserrat .....	45

Carelli, Pasquale . . . . . 1031  
 Carnì, Domenico Luca . . . . . 278  
 Carpentieri, Mario . . . . . 169  
 Cascone, Ernesto . . . . . 221, 226  
 Casinelli, Deborah . . . . . 523  
 Casini, Roberto . . . . . 1031  
 Caspers, Fritz . . . . . 80  
 Castellano, M. . . . . 69  
 Castelli, Andrea . . . . . 760  
 Castrillo, Antonio . . . . . 159  
 Cataldo, Andrea . . . . . 507  
 Cataliotti, Antonio . . . . . 40, 489  
 Catelani, Marcantonio . . . . . 375, 592, 615  
 Cavallari, Adolfo . . . . . 195  
 Cavallo, Filippo . . . . . 862  
 Cavone, Giuseppe . . . . . 620  
 Cavuoto, Giuseppe . . . . . 206  
 Cennamo, Felice . . . . . 534, 661  
 Centuori, Alfonso . . . . . 681  
 Cereatti, Andrea . . . . . 760, 765, 770, 874  
 Cerqueira Bastos, Miguel . . . . . 242  
 Cerri, Roberto . . . . . 501  
 Cerro, Gianni . . . . . 1116  
 Cervantes, Ilse . . . . . 971  
 Cesarelli, Mario . . . . . 602, 606, 610, 786, 790, 856  
 Cestelli Guidi, Mariangela . . . . . 153  
 Cherbaucich, C. . . . . 320  
 Chiadroni, Enrica . . . . . 69, 75  
 Chiarello, Fabio . . . . . 1031  
 Chidichimo, Andrea . . . . . 122  
 Chiorboli, Giovanni . . . . . 807  
 Chiquet, Philippe . . . . . 1041  
 Ciancarini, Paolo . . . . . 743  
 Ciancetta, Fabrizio . . . . . 548  
 Cianchi, Alessandro . . . . . 69, 75  
 Ciani, Lorenzo . . . . . 375, 592, 615, 999  
 Cibella, Sara . . . . . 1031  
 Cice, Giampaolo . . . . . 620  
 Cimmino, Pasquale . . . . . 359  
 Ciobanu, Romeo . . . . . 642  
 Cipriani, G. . . . . 489  
 Ciulla, Giuseppina . . . . . 40  
 Clemente, Fabrizio . . . . . 606, 786  
 Cobo, Adolfo . . . . . 189  
 Cola, Simonetta . . . . . 216  
 Colasanti, Roberto . . . . . 396  
 Concas, Giulio . . . . . 749  
 Conde, Olga M. . . . . 189  
 Corato, Valentina . . . . . 1015  
 Cordella, Francesca . . . . . 331  
 Cosciotti, Barbara . . . . . 102, 408  
 Cosentino, Valentina . . . . . 40  
 Costa, Jorge R. . . . . 885  
 Costanzo, Luigi . . . . . 1005  
 Counsell, Steve . . . . . 749  
 Cozzella, Lorenzo . . . . . 390, 396, 558  
 Crescini, Damiano . . . . . 450

Crescini, Paolo . . . . . 450  
 Cristaldi, Loredana . . . . . 987  
 Cusano, A. . . . . 418

## D

D'Addio, Giovanni . . . . . 602, 610, 856  
 D'Angelo, Giovanni . . . . . 606  
 d'Angelo, Giovanni . . . . . 786  
 D'Apuzzo, Massimo . . . . . 1101  
 D'Arco, Mauro . . . . . 1080  
 D'Aucelli, Giuseppe Maria . . . . . 507  
 D'Innocenzo, Flavio . . . . . 455, 548  
 D'Onofrio, Anna . . . . . 206  
 Dall'Oglio, Giorgio . . . . . 1031  
 Dallet, Dominique . . . . . 336, 353, 709  
 Daponte, Pasquale . . . . . 528  
 De Angelis, Alessio . . . . . 1122  
 De Benedetto, Egidio . . . . . 507  
 De Francesco, Ettore . . . . . 563  
 De Francesco, Ruggero . . . . . 563  
 De Giuseppe, Gianluigi . . . . . 681  
 De Lellis, Giovanni . . . . . 148  
 De Leonardis, Francesco . . . . . 412  
 De Marzi, Gianluca . . . . . 1015  
 De Matteis, Ernesto . . . . . 915, 1057  
 De Paola, Donato . . . . . 1057  
 De Silva, Filomena . . . . . 206  
 De Sio, Antonio . . . . . 153  
 De Vito, Luca . . . . . 473, 528, 1127  
 De Vizia, Maria Domenica . . . . . 159  
 Deckardt, R. . . . . 827  
 Del Giudice, Antonio . . . . . 265  
 Del Río, Joaquín . . . . . 45, 164  
 Delhomme, Georges . . . . . 895  
 Della Corte, Antonio . . . . . 1015  
 Della Croce, Ugo . . . . . 760, 765, 770, 874  
 Della Loggia, Emidio . . . . . 548  
 Della Marca, Vincenzo . . . . . 1036  
 Dente, Giovanni . . . . . 122  
 Derler, Patricia . . . . . 178  
 Dezi, Francesca . . . . . 116  
 Di Candia, Francesco Paolo . . . . . 1127  
 Di Cara, Dario . . . . . 40  
 Di Castro, Mario . . . . . 7, 13  
 Di Crescenzo, Antonia . . . . . 148  
 Di Dio, V. . . . . 489  
 Di Fiore, Vincenzo . . . . . 206  
 Di Giovenale, Domenico . . . . . 69, 75  
 Di Iorio, Angelo . . . . . 743  
 Di Leo, Giuseppe . . . . . 1106  
 Di Nisio, Attilio . . . . . 19, 637  
 di Paolo, Federico . . . . . 102, 408  
 Di Pasquale, Stefano . . . . . 402  
 Di Pirro, Giampiero . . . . . 69, 75  
 Di Sarno, Luigi . . . . . 64  
 Di Tullio, Michele . . . . . 133  
 Diaz-Diaz, Irwin A. . . . . 971  
 Dimiccioli, Vincenzo . . . . . 637

Dimitrijevic, Sasa	926
Dobre, Octavia A.	473
Dorozhovets, Mykhaylo	365
Drago, Alessandro	153
Dressel, Martin	1025
Druart, Sylvain	91
Dudzik, Janusz	1095
Dunkel, Olaf	693, 816, 827, 915
Durandetto, Paolo	1011
Durante, Maria Giovanna	64

## E

Eichberger, Bernd	586, 993
Eichstädt, Sascha	371
Elster, Clemens	371
Esposito, Dario	862
Evangelista, Aldo	127
Evangelista, Lorenza	206

## F

Fabbiano, Laura	714
Fabbrocino, Giovanni	133
Faiella, Giuliana	856
Faifer, Marco	574, 580
Fanucci, Luca	86
Fasci, Eugenio	159
Fascia, Flavia	206
Favuzzi, Giovanni	299
Felder, R.	827
Felger, M. Maximilian	1025
Fernandes, Carlos A.	885
Ferrari, Gianluca	396
Ferrario, Massimo	69, 75
Ferre, Manuel	439
Ferrero, Alessandro	673, 703
Ferrigno, Luigi	265, 523, 1116
Feudale Foti, Elisabetta	221
Fiamozzi Zignani, Chiarasole	1015
Ficcadenti, Luca	80
Fiegna, Claudio	1046
Fiorucci, Edoardo	455, 548
Fiscarelli, Lucio	359, 693, 827
Flandre, Denis	91
Fortuné, Dominique	35
Foussat, A.	904
Francis, Laurent Alain	91
Fravolini, Mario Luca	802
Fretto, Matteo	1011
Funck, Jürgen	675

## G

Gabard, A.	904
Galeotti, F.	418
Galli, Alessio	450
Galliana, Flavio	501, 932
Gallo, Daniele	1005
Gambino, Davide	40
Ganter, R.	827

Gara, Fabrizio	116
Garcia-Allende, Pilar B.	189
Gargiulo, Gaetano	786
Gatti, Giancarlo	69, 75
Gehin, Claudine	895
Geibel, Christoph	1025
Genovese, Antonino	455
Gianfrani, Livio	159
Giaquinto, Nicola	507, 714
Giarnetti, Sabino	402
Ginoux, Cyril	1041
Gioioso, Guido	325
Giordano, M.	418
Giorgianni, F.	69
Giovanni, Finocchio	169
Girone, Mario	839
Giunchi, Giovanni	1020
Glielmo, Luigi	435
Godla, Marek	106
Golinelli, E.	320
Golluccio, Giancarlo	816
Graditi, Giorgio	265
Grandone, Elvira	299
Grimaldi, Domenico	278
Grisetti, Giorgio	429
Guccione, Pietro	293
Guglielmelli, Eugenio	331
Guillemaud, Regis	895
Gühmann, Clemens	675

## H

Hafner, Daniel	1025
Hallmann, Damian	631
Huang, Cheng	513, 569

## I

Iacobescu, Fanel	647, 775
Iacobucci, Giuseppe	144
Iadicicco, A.	418
Ianniello, Giacomo	661
Iannotti, Vincenzo	50
Ierace, Stefano	574
Ilic, Damir	844
Ilin, Konstantin S.	1025
Imbesi, Pina	1063
Istrate, Daniela	35
Iuppariello, Luigi	602, 610, 790, 856

## J

Jacobsen, Frode Fadnes	754
Janeiro, Fernando	880
Janeiro, Fernando M.	885
Jesus, Ch.	656
Jiang, Wei	495
Just, Guillaume	1041
Jędrzejewski, Konrad	253

## K

Kalaitzopoulou, Aikaterini	687
----------------------------	-----

Kantautas, Paulius	305
Kardum, Ivana	31
Kasaei, S.	827
Kayafas, Eleftherios	726
Kazazi, Mario	910
Kazimierczuk, Marian	999
Kimura, Shinzo	289
Kitamura, Akiko	289
Kloukinas, Panos	127
Kolanko, Jerzy	1095
Kolias, Vasilis	726
Kollár, István	231, 237, 669, 671
Kollár, István	248
Komasa, Yukako	289
Kondo, Naoko	812
Kononov, Yuri Grigorievich	25
Konstantakos, Vasileios	687
Kosztantaki, Maria	311
Kostamovaara, Juha	111
Kotikumpu, Toni	993
Kovermann, Jan	13
Kościelnik, Dariusz	341
Kubisa, Stefan	720
Kuczerowski, Joseph	80
Kurtti, Sami	111
Köster, Oliver	920
Kürten Ihlenfeld, Waldemar Guilherme	947

## L

Lacquaniti, Vincenzo	1011
Lahouli, Rihab	353
Lamonaca, Francesco	278
Landi, Carmine	1005
Landim, Regis Pinheiro	947
Lanotte, Luciano	50
Lanzillo, Bernardo	602, 610, 856
Lanzillotti, Marco	932
Lanzolla, Anna Maria Lucia	626
Laopoulos, Theodore	687
Lauria, Adele	148
Lauro, Sebastian Emanuel	102
Lauro, Sebastian Emanuel	408
Lazzaroni, Massimo	574, 580
Lebrasseur, Eric	812
Leccese, Fabio	390, 402, 558, 563
Lee, Edward A.	178
Legena, Claudio	450
Leikanger, Tore	586
Leoni, Roberto	1031
Lerch, Philippe	904
Lerch, Reinhard	55
Liccardo, Annalisa	534, 786, 1080, 1101
Liguori, Consolatina	1110
Lipari, Alessandro	489
Lipták, Jozef	106, 667
Lombardi, Angela	293
Lombardo, Cristian Orazio	794
Lopez, Giorgio	1090

Lopez-Higuera, Jose-Miguel	189
Losito, Onofrio	637
Losito, Roberto	7, 13
Luca, Catalina	647
Luiso, Mario	1005
Lunghi, Giacomo	7
Lupi, Giulia	315
Lušin, Tomáš	844
Lvov, Alexey Arlenovich	478
Löffler, Michael	55
Löhl, F.	827

## M

Maalej, Asma	336
Maciołek, Tadeusz	958, 1052
Magnone, Paolo	1046
Maisto, Domenico	839
Malaric, Roman	31
Malvasi, Angelo	681
Mancuso, Claudio	212
Manna, Carlo	839
Marano, Salvatore	283
Marcelli, Augusto	153
Marchesi, Michele	749
Marchetti, Diego	200
Maremmani, Carlo	862
Marinova, Galia Ilieva	833
Mariscotti, Andrea	953, 964
Markevicius, Vytautas	305
Marletta, Vincenzo	794
Marracci, Mirko	597
Marrese, Attilio	780
Marsala, Giuseppe	40
Martino, Michele	242, 381
Martynov, Pavel Vladimirovich	478
Masalles, Jaume Miquel	45
Mascolo, Luigi	293
Masi, Alessandro	7, 13, 445
Masnicki, Romuald	631
Massimo, F.	69
Massot, Bertrand	895
Mastronardi, Lorenzo	412
Mattei, Elisabetta	102, 408
Mazzilli, Gianluca	1127
Mašláň, Stanislav	652
McAdams, Eric	895
Meli, Leonardo	325
Melkonian, Jeanne	1041
Miceli, R.	489
Miceli, Rosario	467, 976
Michaeli, Linus	106, 667
Micheletti, Roberto	597
Micolau, Gilles	1041
Miele, Gianfranco	1101, 1116
Migliorati, Mauro	80
Mindykowski, Janusz	631
Mirabelli, Valentina	299
Mirapeix, Jesus	189

Mita, Yoshio	812
Miśkowicz, Marek	341
Modzel, Piotr	1095
Molinari, Luca	13
Monaco, Paola	200
Montesi, Maria Cristina	148
Morawski, Roman Zdzislaw	754
Moretti, Luigi	159
Mori, Laura	874
Moschitta, Antonio	665, 802, 1122
Mostacci, Andrea	69, 75, 80
Murgia, Alessandro	749
Musazzi, S.	320
Musz, Przemysław	1095
Muzzi, Luigi	1015
Mylonakis, George	64, 127

## N

Napoli, Ettore	1090
Nastro, Alfonso	174
Navikas, Dangirutis	305
Nico, Giovanni	299
Nihtianov, Stoyan	347
Nojdelov, Roumen	347
Novák, Michael	889
Nováková Zachovalová, Věra	652, 942

## O

Obrzut, Jan	900
Oliva, Gabriele	259
Oliveri, Alberto	445
Ometto, Antonio	455
Ortu, Marco	749
Ospishchev, Mikhail Aleksandrovich	25

## P

Pace, Emanuele	153
Paciello, Vincenzo	265, 1106, 1110
Pallares, Oriol	164
Palmieri, Luca	216
Palumbo, Luigi	80
Paolillo, Alfredo	1106
Paolini, Gabriele	760
Papa, Raffaele	212
Papalillo, Donato	390
Papini, Susanna	615
Pappone, Nicola	602, 610, 856
Parente, R.	418
Pasku, Valter	802
Pasquino, Nicola	780, 790
Pasquino, Vittorio	50
Passaro, Vittorio M.N.	412
Pasuto, Alessandro	216
Patoka, Marek	958, 1052
Pařílková, Jana	889
Penna, Augusto	127
Perini, U.	320
Peruzzi, Agnese	770

Petri, Dario	709
Petrone, Carlo	822
Petrovic, Goran	31
Pettinelli, Elena	102, 408
Pezzetti, Marco	839
Pham, Pascale	895
Picariello, Francesco	528, 1127
Piepgras, Ruben	55
Pietrosanto, Antonio	265, 1110
Piquet, Ferran Bernet	45
Pisco, Marco	418
Pissadakis, Stavros	311
Piuzzi, Emanuele	507
Pizzo, Licia	1031
Platonov, Anatoliy	253
Pogliano, Umberto	937
Polycarpou, Marios	259
Pompeo, Nicola	540, 698
Pompili, Riccardo	69, 75
Popovic Renella, Dragana	926
Popovic, Radivoje S.	926
Postel-Pellerin, Jérémy	1036, 1041
Prattichizzo, Domenico	325, 798
Pretto, Alberto	429
Prioli, Marco	673, 703
Prudeniano, Francesco	637
Punzo, Michele	206
Pálfi, Vilmos	237, 671

## Q

Quagliata, Federico	544
Quero, G.	418

## R

Ragonese, Antonio	455
Ragusa, Antonella	40
Rahkonen, Timo	586, 993
Rainieri, Carlo	133
Rajendran, Aneesh	216
Ramos, Pedro M.	880, 885
Rampazzo, Jerome	868
Rapiano, Sergio	528
Ravaschio, Andrea	874
Reatti, Alberto	592, 999
Rebai, Chiheb	336, 353, 483
Renczes, Balázs	248
Ricci, Marco	1122
Ricciardi, Enrico	50
Riesch, Christian	183, 272
Righetti, Riccardo	544
Rindi, Andrea	615
Rodrigues, Luis	13
Rodriguez de Rivera, Hector Jesus	656
Rodriguez de Rivera, Manuel	656
Rodriguez-Cobo, Luis	189
Roia, Davide	116
Romano, Maria	602, 606, 610, 786, 790
Romano, Pietro	467, 976

Roncaglione, Luca	97, 501
Rovini, Erika	862
Rudigier, Manfred	272
Rudnev, Vyacheslav Yuryevich	25
Ruffo, Massimiliano	13
Ruiz-Lombera, Ruben	189
Russenschuck, Stephan	139, 693, 822, 910, 915, 920
Russo, Fabrizio	850
Rzepka, Dominik	341

## S

Sabato, Luca	1068
Sabbatini, Lucia	1031
Salceanu, Alexandru	647, 775
Salicone, Simona	673, 703
Saliga, Ján	106, 667
Salvant, Benoit	80
Salvietti, Gionata	325, 423
Sanfilippo, Stephane	827, 904
Santamaria, Amilcare Francesco	283
Santillo, Luca	731
Santos, José	880
Santucci de Magistris, Filippo	133
Sarmiento, Roberto	656
Satler, Massimo	1
Sato, Hitoshi	289
Savino, Mario	19
Sawamura, Tomoki	812
Scarano, Valeria Leonarda	626
Scheffler, Marc	1025
Scheggi, Stefano	423, 798
Schenato, Luca	216
Schenk, Wolfgang	183
Schiano Lo Moriello, Rosario	534, 780
Schirripa Spagnolo, Giuseppe	390, 396, 558
Schlegel, Katrin	1025
Schreiner, Thomas	642
Schuss, Christian	586, 993
Sciuto Salvatore Andrea	315
Scorza, Andrea	315
Scotti, Veronica	385
Scotto di Santolo, Anna	127, 206
Scotto di Vettimo, Paolo	206
Seiro, Silvia	1025
Sellone, Marco	1074
Serazio, Danilo	937
Serchi, Valeria	770
Sereni, Bianca	375
Setola, Roberto	259
Severino, Giordana	827, 920
Shoaib, Noshewan	1074
Siano, Gianmichele	435
Sica, Stefania	64, 206
Siegel, Michael	1025
Silva, Enrico	540, 698
Silvestri, Francesco	206
Simonelli, Armando Lucio	64, 127
Simonini, Paolo	216

Skorodumova, Nina A.	554
Smirnova, Natalia N.	554
Socorro, Fabiola	656
Sommella, Paolo	1110
Sorli, Amrit	518
Sosin, Mateusz	1057
Sosso, Andrea	501, 1011
Sottile, Cesare	283
Souissi, Souha	483
Spadavecchia, Maurizio	19, 626, 637
Spasic, Sasa	926
Spataro, Bruno	80
Spataro, Ciro	467, 976
Staderini, Enrico M.	868
Stefănescu, Dan Mihai	461
Steglich, Frank	1025
Stellato, Aniello	661
Stockner, Markus	816
Storace, Marco	445
Strollo, Antonio G.M.	1090
Sutor, Alexander	55
Svetlov, Michael Semenovich	478
Szeląg, Adam	958, 1052
Szyduczyński, Jakub	341
Síra, Martin	652, 942

## T

Takaysuji, Toshihiro	289
Tamba, Bogdan	642
Tarallo, Daniela	206
Taylor, Colin A.	64, 127
Tchobanova, Zdravka	833
Tellini, Bernardo	597
Thiemann, Markus	1025
Tinë, Giovanni	40, 489
Tiscia, Giovanni Luca	299
Toma, Daniel Mihai	45
Tomasello, Riccardo	169
Tonelli, Roberto	749
Torokhtii, Kostiantyn	540, 698
Torrioli, Guido	1031
Toscani, Sergio	580
Totani, Gianfranco	200
Touati, Farid	450
Traverso, Pier Andrea	1046
Trinca, Daniele	402
Trinchera, Bruno	97, 937
Tripicchio, Paolo	1
Trojaniello, Diana	765, 874
Trotta, Amerigo	714
Tudosa, Ioan	528
Turtù, Simonetta	544

## U

Uchiyama, Koji	289
----------------	-----

## V

Vacca, Gaetano	714
----------------	-----

Vaccarezza, Cristina . . . . .	69, 75
Vadursi, Michele . . . . .	534
Valdiande, Jose J. . . . .	189
Valinevicius, Algimantas . . . . .	305
Vergura, Silvano . . . . .	981
Vesco, Felice . . . . .	40
Veselý, Jaroslav . . . . .	889
Viciunas, Justas . . . . .	305
Villa, Fabio . . . . .	69, 75
Villalba, José Francisco Blanco . . . . .	642
Viola, Fabio . . . . .	467, 976
Viola, Rosario . . . . .	1015
Virosztek, Tamàs . . . . .	231
Virosztek, Tamàs . . . . .	669, 671
Vitali, Fabio . . . . .	743
Vitelli, Massimo . . . . .	1005
Vitkovič, Vojtech . . . . .	667
Voigt, Dirk . . . . .	347
Vrankovic, V. . . . .	827

**W**

Wakrim, Tariq . . . . .	1036
Walckiers, Luis . . . . .	827

Wang, Guojiao . . . . .	569
Wang, Nan . . . . .	513
Warsza, Zygmunt L. . . . .	720
Warsza, Zygmunt Lech . . . . .	365
Wendt, Manfred . . . . .	86
Wierzbicki, Zbigniew . . . . .	1095
Winiiecki, Wiesław . . . . .	754
Wu, Jianhui . . . . .	513

**Y**

Yacoot, Andrew . . . . .	347
Yang, Weiguang . . . . .	569
Yashchyshyn, Yevhen . . . . .	754

**Z**

Zanobini, Andrea . . . . .	375
Zhang, Qi . . . . .	495
Ziadé, Francois . . . . .	35
Zickler, Thomas . . . . .	816
Zimmaro, Paolo . . . . .	60
Zimmer, Michael . . . . .	178
Zollo, Loredana . . . . .	331
Zorzetti, Silvia . . . . .	86