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SMART CITIES ECOSYSTEM.GR
Ελλάδα 2.0 ΕΘΝΙΚΟ ΣΧΕΔΙΟ ΑΝΑΚΑΜΨΗΣ ΚΑΙ ΑΝΘΕΚΤΙΚΟΤΗΤΑΣ
Με τη χρηματοδότηση της Ευρωπαϊκής Ένωσης
NextGenerationEU
ΓΕΝΙΚΗ ΓΡΑΜΜΑΤ ΕΡΕΥΝΑΣ ΚΑΙ ΚΑΙΝΟΤ

# 1 Προσθήκες στο Π7.2, Κεφ. 3: “Δράσεις Διάχυσης”

## 1.1 Επιστημονικές Δημοσιεύσεις

**Design and Implementation of Scalable and Low-Latency LoRaWAN IoT Architecture for Smart Cities [1]**

**Conference/Date:** 2025 IEEE Symposium on Computers and Communications (ISCC)
**Authors:** A. Christopoulou, G. T. Karetsos and F. Gioulekas
**Keywords:** Smart cities, Scalability, LoRaWAN, Computer architecture, Jitter, Network architecture, Performance analysis, Internet of Things, Servers, Resource management, LoRaWAN, FIWARE, Docker, MQTT, TLS, jitter, delay, energy consumption

**Abstract:**

Advances in the Internet of Things (IoT) technologies are revolutionizing data collection, communication and processing for various smart cities applications such as environmental monitoring. This paper introduces a network architecture leveraging LoRaWAN telecommunication components and servers, FIWARE IoT Platform and other containerized mechanisms to bolster and achieve both near-real-time air quality monitoring, historical data analysis and visualization. The proposed system bridges diverse IoT subsystems components while ensuring secure, scalable and efficient data transmission through various communication protocols and in particular TLS-encrypted MQTT. Performance analysis of our system demonstrates minimal latency, predictable jitter and an optimized resource utilization. This architecture showcases how integrating open-source components can address many IoT deployment challenges, supporting scalability, interoperability and adjustment to a variety of IoT applications, including smart cities.

**Machine Learning Enabled Integrated Sensing and Communication for Smart 6G Environments [2]**

**Conference/Date:** 2025 28th Conference on Innovation in Clouds, Internet and Networks (ICIN)
**Authors:** P. Tirchas and G. T. Karetsos
**Keywords:** 6G mobile communication, Wireless sensor networks, Technological innovation, Smart cities, Wireless networks, OFDM, Machine learning, Integrated sensing and communication, Hardware, Next generation networking, 6G wireless, ISAC, machine learning, OFDM, FMCW

**Abstract:**

Integrated sensing and communication (ISAC) inherently combines the functions of sensing and communication, leveraging wireless and hardware resources for the mutual benefit. ISAC is widely expected to play a pivotal role in next-generation wireless networks, supporting a broad spectrum of emerging applications by transmitting signals that serve both data communication and sensing purposes. This dual functionality can be applied in various contexts, such as environmental monitoring, smart cities, and industrial automation. In this work we present an experimental ISAC framework that serves as a proof of concept regarding the capabilities of this technology in future wireless networking environments. Furthermore, the acquired results corroborate that ISAC in combination with AI/ML techniques and in particular Convolutional Neural Networks (CNNs) is an important enabler for creating smart 6G communication environments.

**An Open-Source SIEM and XDR Monitoring Framework Towards Holistic IoT Security [3]**

**Conference/Date:** 2025 IEEE Middle East Communications Conference (MECOM)
**Authors:** Sotirios Milionis and George T. Karetsos
**Keywords:** Internet of Things, Cybersecurity, Real-time Monitoring, Threat Detection, Incident Response

**Abstract:**

Due to the complexity of today's networked device ecosystem the detection and prevention of cyber-attacks is quite challenging and only possible via the correct tools and technologies in order to effectively identify vulnerabilities, mitigate potential threats, and ensure the system's integrity and availability. Protecting the diverse systems within a company is undoubtedly a challenging task, and with the proliferation of the Internet of Things (IoT) devices, it has become even more complex due to their heterogeneity, limited security capabilities, and increased attack surface. A variety of proactive technologies are required to achieve effective cybersecurity, with Security Information and Event Management (SIEM) and Extended Detection and Response (XDR) being among the most critical. This paper focuses on the implementation of an open-source SIEM and XDR solution, emphasizing its role in strengthening the security posture of small to medium-sized businesses in a costeffective and scalable manner. The implemented solution includes a Network Intrusion Detection and Prevention System (IDS/IPS), along with the deployment of the Elastic Stack, where the IDS/IPS monitors network traffic for suspicious activity, detects potential threats in real time, and automatically blocks or mitigates attacks, thereby directly contributing to a stronger security posture.

**FedSemiSelf: A Hybrid Semi-Self-Supervised Federated Learning Framework [4]**

**Conference/Date:** 2025 3rd International Conference on Federated Learning Technologies and Applications (FLTA)

**Authors:** Filippou, F. Foukalas and T. Tsiftsis

**Keywords:** Training, Computer vision, Wireless sensor networks, Federated learning, Wireless networks, Scalability, Supervised learning, Semisupervised learning, Sensors, Synchronization, federated learning, semi-supervised learning, self-supervised learning, pseudo-labeling, computer vision

**Abstract:**

In this paper, we propose FedSemiSelf, a novel hybrid federated learning framework that addresses the challenges of limited labeled data and statistical heterogeneity in federated settings by combining self and semi supervised learning approaches. It integrates a contrastive learning objective to build robust local representations without requiring labels, while employing a confidence-based pseudo-labeling strategy that progressively introduces unlabeled data based on their estimated reliability. A curriculum scheduler dynamically controls training stages by evaluating model consistency across clients, enabling a stable and effective transition between self-supervised and pseudo-supervised phases. To enhance memory efficiency and representation diversity, each client maintains a coreset of representative samples drawn from local data streams. FedSemiSelf demonstrates strong potential for real-world decentralized learning scenarios such as smart sensing, edge intelligence, and privacy-preserving computer vision.

**Edge Deep Learning for Low Capabilities Devices [5]**

**Conference/Date:** 2025 3rd International Conference on Federated Learning Technologies and Applications (FLTA)

**Authors:** F. Filippou, F. Foukalas and T. Tsiftsis

**Keywords:** Deep learning, Performance evaluation, YOLO, Quantization (signal), Accuracy, Image edge detection, Computational modeling, Nanoscale devices, Speech to text, Image classification, deep learning, object detection, edge devices, pruning, quantization, YOLO

**Abstract:**

Nowadays, Deep Learning (DL) is being used to construct many applications in domains such as object detection, image classification, speech to text etc. Deep Neural Networks (DNNs) are the core of Deep Learning as they offer remarkable accuracy and performance across various tasks. Despite their powerful capabilities, DNNs often require substantial computational resources, which can be challenging to manage, especially when deploying them on edge devices. So, these

models have to be optimized before being deployed to these devices. Optimizing a model means making it smaller and more efficient without losing too much performance. Even though techniques like pruning reduce the number of parameters, the goal is to keep accuracy and speed as close as possible to the original. We are going to present a hybrid solution combining two techniques, pruning and quantization. Pruning is the process of eliminating inessential weights and connections in order to reduce the model size. Once the unnecessary parameters are removed, the model is quantized by converting the weights of the remaining parameters from 32 floating point precision to half or to INT8. We verify and validate the performance of this hybrid approach using the COCO dataset (contains 80 classes) and the pre-trained YOLOv8 model. At the final stage, the hybrid model is deployed on two different edge devices for benchmarking, the NVIDIA Jetson Nano (4GB) and the Raspberry Pi 5 (16GB).

**Age of Incorrect Information With Hybrid ARQ Under a Resource Constraint for N-Ary Symmetric Markov Sources [6]**

**Published:** IEEE Transactions on Networking
**Authors:** K. Bountrogiannis, A. Ephremides, P. Tsakalides and G. Tzagkarakis
**Keywords:** Decoding, Measurement, Receivers, Transmitters, Distortion, Real-time systems, Protocols, Time measurement, Delays, Standards, Remote monitoring, information freshness, Age of Incorrect Information (AoII), hybrid automatic repeat request (HARQ), constrained Markov decision processes

**Abstract:**

The Age of Incorrect Information (AoII) is a recently proposed metric for real-time remote monitoring systems. In particular, AoII measures the time the information at the monitor is incorrect, weighted by the magnitude of this incorrectness, thereby combining the notions of freshness and distortion. This paper addresses the definition of an AoII-optimal transmission policy in a discrete-time communication scheme with a resource constraint and a hybrid automatic repeat request (HARQ) protocol. Considering an N-ary symmetric Markov source, the problem is formulated as an infinite-horizon average-cost constrained Markov decision process (CMDP).

Interestingly, it is proved that, under some conditions, the optimal transmission policy is to never transmit. This reveals a region of the source dynamics where communication is inadequate in reducing the AoII. Elsewhere, there exists an optimal transmission policy, which is a randomized mixture of two discrete threshold-based policies that randomize on at most one state. The optimal threshold and the randomization component are derived analytically. Numerical results illustrate the impact of the source dynamics, channel conditions, and resource constraints on the average AoII.

**Variable-Length Stop-Feedback Coding for Minimum Age of Incorrect Information [7]**

**Conference/Date:** MOBIHOC '24: Proceedings of the Twenty-fifth International Symposium on Theory, Algorithmic Foundations, and Protocol Design for Mobile Networks and Mobile Computing

**Authors:** Konstantinos Bountrogiannis, Ioannis Papoutsidakis, Anthony Ephremides, Panagiotis Tsakalides, and George Tzagkarakis

**Keywords:** Networks → Network performance analysis, Network per- formance modeling, • Mathematics of computing → Coding theory, Information theory, Mathematical optimization.

**Abstract:**

The Age of Incorrect Information (AoII) is studied within the context of remote monitoring a Markov source using variable-length stop-feedback (VLSF) coding. Leveraging recent results on the non-asymptotic channel coding rate, we consider sources with small cardinality, where feedback is non-instantaneous as the transmitted information and feedback message have comparable lengths. We focus on the feedback sequence, i.e. the times of feedback transmissions, and derive AoII-optimal and delay-optimal feedback sequences. Our results showcase the impact of the feedback sequence on the AoII, revealing that a lower average delay does not necessarily correspond to a lower average AoII. We discuss the implications of our findings and suggest directions for coding scheme design.

**Forecasting PM2.5 and NO2 concentrations in Patras using low-cost sensors and machine learning [8]**

**Conference/Date:** 2025 IEEE International Smart Cities Conference (ISC2)
**Authors:** I. D. Apostolopoulos, G. Fouskas and S. N. Pandis
**Keywords:** Pollution, Smart cities, Atmospheric modeling, Weather forecasting, Predictive models, Air quality, Sensor systems, Sensors, Pollution measurement, Forecasting, Air Quality, Machine Learning, Forecast Models

**Abstract:**

We present a machine learning methodology for forecasting next day's PM2.5 and NO2 concentrations in Patras, Greece, using a sequence-to-sequence LSTM neural network architecture trained on data from a low-cost ENSENSIA sensor system and a meteorological station in Patras. The model integrates recent pollutant trends, temporal variables, and forecasted meteorology through an exogenous-aware encoderdecoder design with an attention mechanism. We used historical PM2.5 and NO2 concentration measurements from ENSENSIA and meteorological variables from a local weather station to build and train the model. Validation over December 2024 showed promising results, achieving a fractional error of 0.45 and bias of 0.01 for PM2.5, and 0.17 and 0.02, respectively, for NO2. The model underestimated PM2.5 peaks, highlighting limitations in modelling pollution events driven by atmospheric chemistry. Our results underscore the potential of combining low-cost sensing and machine learning for urban air quality monitoring.

**SEDS: Designing a Smart Energy Data Space for Secure and Trustworthy Real-Time Sharing of Household Energy Data [9]**

**Conference/Date:** 2025 IEEE International Smart Cities Conference (ISC2)
**Authors:** D. Stavropoulos, I. Syrigos, P. Tzimotoudis, K. Kyriakou and T. Korakis
**Keywords:** Smart cities, Ecosystems, Semantics, Smart homes, Aerospace electronics, Real-time systems, Demand response, Smart grids, Stakeholders, Interoperability, Smart Energy Systems, Data Spaces, Smart Grids, Smart Homes

**Abstract:**

We present a machine learning methodology for forecasting next day's PM2.5 and NO2 concentrations in Patras, Greece, using a sequence-to-sequence LSTM neural network architecture trained on data from a low-cost ENSENSIA sensor system and a meteorological station in Patras. The model integrates recent pollutant trends, temporal variables, and forecasted meteorology through an exogenous-aware encoderdecoder design with an attention mechanism. We used historical PM2.5 and NO2 concentration measurements from ENSENSIA and meteorological variables from a local weather station to build and train the model. Validation over December 2024 showed promising results, achieving a fractional error of 0.45 and bias of 0.01 for PM2.5, and 0.17 and 0.02, respectively, for NO2. The model underestimated PM2.5 peaks, highlighting limitations in modelling pollution events driven by atmospheric chemistry. Our results underscore the potential of combining low-cost sensing and machine learning for urban air quality monitoring.

**Ημιαγώγιμες μεταλλο-οργανικές δομές βασισμένες σε Cu ως αισθητήρες υδρογόνου**

**Conference/Date:** Συνεδρία VII «Φυσική – Θεωρητική – Υπολογιστική Χημεία»
**Authors:** Α. Σφακιανού, Ε. Σκλήρη, Ε. Γκαγκαουδάκης, Β. Μπίνας

**Abstract:**

Οι αισθητήρες αερίων αποτελούν απαραίτητα εργαλεία για την ανίχνευση συγκεντρώσεων αερίων που δεν είναι δυνατό να γίνουν αντιληπτές με τις ανθρώπινες αισθήσεις. Τα τελευταία χρόνια, η ανίχνευση του υδρογόνου έχει γίνει ιδιαίτερα σημαντική λόγω της χρήσης του ως καθαρή και ανανεώσιμη πηγή ενέργειας. Η ανάγκη ανίχνευσης του υδρογόνου προκύπτει από το γεγονός ότι είναι ένα εξαιρετικά εύφλεκτο αέριο. Η ανίχνευση του υδρογόνου είναι, επομένως, κρίσιμη για την πρόληψη ατυχημάτων και την εξασφάλιση της ασφάλειας και της αποτελεσματικότητας των ενεργειακών συστημάτων. Για τους παραπάνω λόγους υπάρχει έντονη ανάγκη για γρήγορους και χαμηλού κόστους αισθητήρες υδρογόνου. Στόχος της παρούσας μελέτης είναι η βελτίωση των χρόνων απόκρισης και επαναφοράς των αισθητήρων υδρογόνου μέσω της τροποποίησης του ημιαγωγού CuSCN με νανοσωματίδια πλατίνας (Pt). Συγκεκριμένα, πραγματοποιήθηκε φωτοεναπόθεση νανοσωματιδίων πλατίνας σε διαφορετικά ποσοστά (0.1%,

0.25%, 0.5% και 0.75% w/w) στον ημιαγωγό CuSCN. Το CuSCN είναι ένας p-τύπου ημιαγωγός με εξαιρετικές ηλεκτρονικές και μηχανικές ιδιότητες, και έχει μελετηθεί ως αισθητήρας υδρογόνου επιδεικνύοντας εξαιρετικά αποτελέσματα (Kabitakis et al., 2022). Ειδικότερα, ο αισθητήρας CuSCN έδειξε μεγάλη σταθερότητα και εξαιρετικά χαμηλά όρια ανίχνευσης (200 ppm) σε θερμοκρασία δωματίου και υπό χαμηλή τάση τροφοδοσίας ίση με 0.1 V. Ωστόσο, οι χρόνοι απόκρισης και επαναφοράς του αισθητήρα ήταν αρκετά μεγάλοι. Με την εναπόθεση νανοσωματιδίων πλατίνας, σημειώθηκε σημαντική βελτίωση στους χρόνους απόκρισης κατά 90%, φτάνοντας τα 16 s στα 200 ppm για το 0.5%Pt-CuSCN από τα αρχικά 3 min. Ομοίως, ο χρόνος επαναφοράς μειώθηκε στα 36 s στα 200 ppm για το 0.25%Pt-CuSCN από τα αρχικά 6 min. Αυτή η βελτίωση οφείλεται στην αύξηση της ενεργής επιφάνειας καθώς και την ενίσχυση της καταλυτικής δραστηριότητας παρουσία της πλατίνας. Επομένως, το Pt-CuSCN είναι ένα πολλά υποσχόμενο υλικό για τη ανίχνευση υδρογόνου σε χαμηλούς χρόνους απόκρισης με ταυτόχρονη χαμηλή κατανάλωση ενέργειας.

**CU2O_Nanocubes_as_Gas_Sensing_Elements_for_Food_Packaging_Applications [10]**

**Conference/Date:** Transparent Conductive Oxides 2024
**Authors:** A. Sfakianou, E. Gagaoudakis, E. Mantsiou, S.H Anastasiadis, V. Binas

**Abstract:**

Intelligent packaging has attracted research interest during the last decades. More specifically, food packaging is of great importance due to the utmost need to monitor and maintain food quality until consumption. Thus, there is a high demand for sensors capable of detecting gases such as CO2, emitted by packaged meat or chicken which serve as freshness indicators. In the present work, a sensor based on Cu2O nanocubes was fabricated and tested against CO2 at room temperature. Cu2O nanocubes were synthesized by solution-based methods and deposited on commercial interdigitated electrodes. Specifically, the Cu2O-based sensor successfully detected down to 5% CO2 (50,000 ppm) in the ambient atmosphere, at room temperature, with a response time of less than 90 s. This level of CO2 is in the range that indicates the unsuitability of packaged meat for consumption. Furthermore, the sensor was able to maintain its response to CO2 after

being stored in the fridge for 20 days, showcasing its endurance under food maintenance conditions.

## 1.2 Συμμετοχή σε Εκδηλώσεις

**Copper Coordination Polymer Semiconductor for Hydrogen Sensors**

**Conference/Date: Invited Talk** NN25, 8-11/7/2025, Thessaloniki, Greece
**Authors:** A. Sfakianou, E. Skliri, E. Gagaoudakis, C.-P. Tsichlis, S.H Anastasiadis, V. Binas
**Abstract:**

CuSCN is a p-type semiconductor with excellent electronic and mechanical properties. It appears in two bulk polymorph phases, namely α-CuSCN and β-CuSCN. The former is an orthorhombic phase of the Pbca space group, while the latter, found more often, is a wurtzite structure. Moreover, it is highly transparent in the visible region of the electromagnetic spectrum having an optical energy bandgap of about 3.4 eV, while it has interesting hole-transport characteristics. As a result, it has been studied as a hydrogen sensor, demonstrating excellent performance. In particular, the CuSCN sensor exhibited high stability and extremely low detection limits (200 ppm) at room temperature and under a low applied voltage of 0.1 V. However, the sensor's response and recovery times were quite long. In this work, CuSCN was modified with platinum (Pt) nanoparticles in an attempt to improve its gas sensing properties. Specifically, platinum nanoparticles were photo-deposited at different concentrations (0.1%, 0.25%, 0.5%, and 0.75% w/w) on the CuSCN semiconductor. With the deposition of platinum nanoparticles, a significant improvement in response times was observed, reducing to 16 s at 200 ppm for 0.5%Pt-CuSCN, compared to the initial 3 minutes. This improvement is attributed to the increase in active surface area and the enhanced catalytic activity due to the presence of platinum.

# 2 Αναφορές

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