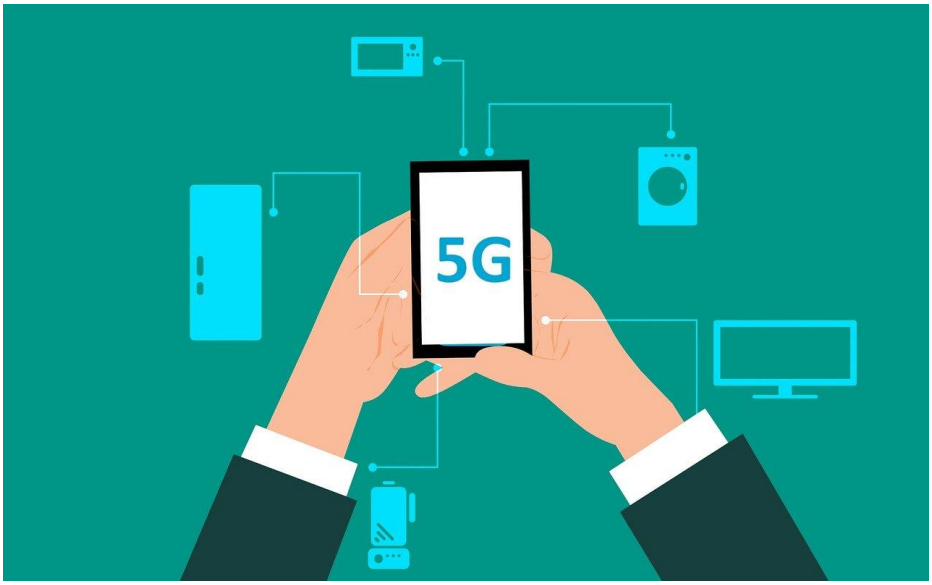
TECHNOLOGIE 5G

Bulletin de veille scientifique : Février 2024



Objectifs : réaliser une veille scientifique sur la technologie 5G

La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS. Les éléments issus de cette veille sont fournis sans garantie d'exhaustivité. Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.

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Généralités

Aucun article dans ce bulletin.

Performances et sécurité

SDN-Based Congestion Control and Bandwidth Allocation Scheme in 5G Networks.

Yang D, Tsai WT. *Sensors (Basel)*. 2024 Jan 24;24(3).

5G cellular networks are already more than six times faster than 4G networks, and their packet loss rate, especially in the Internet of Vehicles (IoV), can reach 0.5% in many cases, such as when there is high-speed movement or obstacles nearby. In such high bandwidth and high packet loss network environments, traditional congestion control algorithms, such as CUBIC and bottleneck bandwidth and round-trip propagation time (BBR), have been unable to balance flow fairness and high performance, and their flow rate often takes a long time to converge. We propose a congestion control algorithm based on bottleneck routing feedback using an in-network control mode called bottleneck routing feedback (BRF). We use SDN technology (OpenFlow protocol) to collect network bandwidth information, and BRF controls the data transmission rate of the sender. By adding the bandwidth information of the bottleneck in the option field in the ACK packet, considering the flow fairness and the flow convergence rate, a bandwidth allocation scheme compatible with multiple congestion control algorithms is proposed to ensure the fairness of all flows and make them converge faster. The performance of BRF is evaluated via Mininet. The experimental results show that BRF provides higher bandwidth utilization, faster convergence rate, and fairer bandwidth allocation than existing congestion control algorithms in 5G cellular networks.

Lien vers l'article

Antennes

Design and optimization of metamaterial-based highly-isolated MIMO antenna with high gain and beam tilting ability for 5G millimeter wave applications.

Esmail BAF, Koziel S. *Sci Rep*. 2024 Feb 8;14(1):3203.

This paper presents a wideband multiple-input multiple-output (MIMO) antenna with high gain and isolation, as well as beam tilting capability, for 5G millimeter wave (MMW) applications. A single bow-tie antenna fed by a substrate-integrated waveguide (SIW) is proposed to cover the 28 GHz band (26.5-29.5 GHz) with a maximum gain of 6.35 dB. To enhance the gain, H-shaped metamaterial (MM)-based components are incorporated into the antenna substrate. The trust-region (TR) gradient-based search algorithm is employed to optimize the H-shape dimensions and to achieve a maximum gain of 11.2 dB at 29.2 GHz. The MM structure offers zero index refraction at the desired range. Subsequently, the MIMO system is constructed with two vertically arranged radiators. Another MM, a modified square resonator (MSR), is embedded between the two radiators to reduce the mutual coupling and to tilt the antenna main beam. Herein, the TR algorithm is again used to optimize the MSR dimensions, and to enhance the isolation to a maximum of 75 dB at 28.6 GHz. Further, the MSR can tilt the E-plane radiation by ± 20° with respect to the end-fire direction when alternating between the two ports' excitation. The developed system is validated experimentally with a good matching between the simulated and measured data.
Lien vers l'article

Dual-band independently tunable 8-element MIMO antenna for 5G smartphones.

Sufyan A, Khan KB, Zhang X, Siddiqui TA, Aziz A. *Heliyon*. 2024 Feb 29;10(4):e25712.

In this paper, a multi-input multi-output (MIMO) antenna for future mobile phone applications operating in sub-6 GHza using a novel combination of an E-shaped slot placed on the ground plane and an F-shaped probe is used to achieve a dual-band independently tunable antenna. The proposed antenna is not only self-isolated but it has also effectively achieved high isolation of greater than 17 dB in both 3.5 GHz (3.4 - 3.6 GHz) and 4.7 GHz (4.6 - 4.87 GHz) frequency bands for 8-element MIMO antenna configuration for 5G smartphones. The simple yet compact size of (0.035 λ0Image 1 0.23 λ0), of the slot antenna produces a balanced slot mode which not only reduces the ground effects but also improves the isolation between two adjacent input ports. The novelty of the proposed dual-band MIMO antenna is its independent control of each band across a wide frequency band and results demonstrate higher efficiency (64% - 71%) and diversity gain performance in both frequency bands. Furthermore, the antenna is designed by the meticulous configurations of 8-antenna elements without employing any external decoupling structure to attain the desired polarization diversity. The prototype of this 8-element MIMO antenna is also fabricated and measured to validate its simulated performance. The simple structure of the proposed design and high efficiency makes it a promising candidate for 5G smartphones.

Lien vers l'article

Architecture réseau

Infrastructure-Wide and Intent-Based Networking Dataset for 5G-and-beyond AI-Driven Autonomous Networks.

Andrade-Hoz J, Wang Q, Alcaraz-Calero JM. *Sensors (Basel)*. 2024 Jan 25;24(3).

In the era of Autonomous Networks (ANs), artificial intelligence (AI) plays a crucial role for their development in cellular networks, especially in 5G-and-beyond networks. The availability of high-quality networking datasets is one of the essential aspects for creating data-driven algorithms in network management and optimisation tasks. These datasets serve as the foundation for empowering AI algorithms to make informed decisions and optimise network resources efficiently. In this research work, we propose the IW-IB-5GNET networking dataset: an infrastructure-wide and intent-based dataset that is intended to be of use in research and development of network management and optimisation solutions in 5G-and-beyond networks. It is infrastructure wide due to the fact that the dataset includes information from all layers of the 5G network. It is also intent based as it is initiated based on predefined user intents. The proposed dataset has been generated in an emulated 5G network, with a wide deployment of network sensors for its creation. The IW-IB-5GNET dataset is promising to facilitate the development of autonomous and intelligent network management solutions that enhance network performance and optimisation.

Lien vers l'article

Efficacité énergétique

Aucun article dans ce bulletin.

Autres équipements

(Ni(1/3)Nb(2/3))(4+)-Improved High-K Ba(3)Ti(4)Nb(4)O(21) Microwave Dielectric Ceramics for Miniaturized All-Ceramic Radomes with 5G Beam-Splitting Function.

Tang T, Ye F, Hua H, Li C, Shen J. *Inorg Chem*. 2024 Mar 4;63(9):4404-11.

With the rapid development of 5G communication technology, microwave dielectric ceramics with high dielectric constants are very conducive to the miniaturization of passive devices. Here, Ba(3)Ti(4-x)(Ni(1/3)Nb(2/3))(x)Nb(4)O(21) (BTN ∼ NN, 0.03 ≤ x ≤ 0.15) ceramics with hexagonal phases are synthesized via the solid-phase route. The composite (Ni(1/3)Nb(2/3))(4+) ion substitution strategy can substantially improve the microwave dielectric properties of the Ba(3)Ti(4)Nb(4)O(21) (BTN) ceramic. The ε(r) and Q × f values depend on the ionicity (Nb-O bonds) and lattice energies (Nb(1)-O3 and Nb(1)-O2(1) bonds). The microwave dielectric properties of the BTN ∼ NN (x = 0.09) ceramic sintered at 1250 °C are ε(r) = 60.3, Q × f = 22073 GHz, and τ(f) = 78.1 ppm/°C. A miniaturized all-ceramic radome (@400 mm × 400 mm × 8 mm) for 5G beam-splitting function is designed and demonstrated using this ceramic. Compared to other radomes designed for other work utilizing low ε(r), the size of this radome has been reduced by 3/7. The reflection coefficients of the beam splitting function are all 0.73, and the phase shifts are all 360°. This work contributes to the development of miniaturized passive devices from a materials point of view.

Lien vers l'article

Applications industrielles

Efficient content caching for 5G assisted vehicular networks.

Ahmed F, Alsamani B, Alkhathami M, Alsadie D, Alosaimi N, Alenzi B, Nkenyereye L. *Sci Rep*. 2024 Feb 18;14(1):4012.

Traffic congestion is one of the major challenges faced by daily commuters in smart cities. An autonomous transportation system with a 5 G-based Cellular Vehicle-to-Everything (C-V2X) communication system is the solution to meet the traffic challenges faced in smart cities. Vehicular networks provide wireless connectivity to enable a large number of connected vehicle applications. Vehicular networks allow vehicles to share their emergency and infotainment traffic by following vehicle-to-vehicle (V2V) or by using vehicle-to-infrastructure (V2I) communication. The infrastructure of vehicular networks mainly comprises multiple Road Side Units (RSUs). Fog computing nodes are placed adjacent to these RSUs to provide quick access to vehicles. For infotainment traffic, vehicles intend to download their required content from the content provider. Caching the same contents from the nearby fog computing node significantly reduces delay with improved quality of service. As there are millions of contents with varying sizes, caching all demanded contents on these fog nodes is not possible due to their limited caching capacity. In this work, we propose an improved content caching scheme for fog nodes to satisfy vehicles and content providers for fair content placement. The proposed algorithm is based on a modified Gale-Shapley technique that considers factors such as content popularity, vehicle connectivity, and quality of the communication channel to optimize the content caching process. Simulation results show that the proposed technique caches a higher number of popular contents with lower downloading time.

Lien vers l'article

Exploring Interference Issues in the Case of n25 Band Implementation for 5G/LTE Direct-to-Device NTN Services.

Pastukh A, Tikhvinskiy V, Devyatkin E. *Sensors (Basel)*. 2024 Feb 17;24(4).

This paper delves into an interference analysis, focusing on the forthcoming Starlink Generation 2 satellites, stated to operate within the 1990-1995 MHz frequency band. The aim is to assess the potential interference from this Starlink system to the satellite receivers of mobile satellite systems (MSSs), which are set to function within the 1980-2010 MHz range, and satellite receivers of the NTN systems, which are planned to operate in the n256 bands, defined by the 3GPP specifications. Through simulation-based evaluations, both single-entry and aggregate interference levels from Starlink to MSSs and NTN systems are comprehensively explored. To estimate the interference impact, several protection criteria were used. The study is in line with the Recommendations of International Telecommunication Union (ITU-R) and common approaches that are used when performing compatibility studies between satellite systems. The findings of this study demonstrate the feasibility of utilizing the n25 band for NTN direct-to-device services.

Lien vers l'article

Tour guide robot: a 5G-enabled robot museum guide.

Rosa S, Randazzo M, Landini E, Bernagozzi S, Sacco G, Piccinino M, Natale L. *Front Robot AI*. 2023;10:1323675.

This paper presents and discusses the development and deployment of a tour guide robot as part of the 5 g-TOURS EU research project, aimed at developing applications enabled by 5G technology in different use cases. The objective is the development of an autonomous robotic application where intelligence is off-loaded to a remote machine via 5G network, so as to lift most of the computational load from the robot itself. The application uses components that have been widely studied in robotics, (i.e., localization, mapping, planning, interaction). However, the characteristics of the network and interactions with visitors in the wild introduce specific problems which must be taken into account. The paper discusses in detail such problems, summarizing the main results achieved both from the methodological and the experimental standpoint, and is completed by the description of the general functional architecture of the whole system, including navigation and operational services. The software implementation is also publicly available.

Lien vers l'article

Applications médicales

Correction: Telemedicine network latency management system in 5G telesurgery: a feasibility and effectiveness study.

Li C, Zheng J, Zhang X, Luo L, Chu G, Zhao J, et al. *Surg Endosc*. 2024 Mar;38(3):1665.

Lien vers l'article

Intelligent deep learning-based disease monitoring system in 5G network using multi-disease big data.

Das A. *J Biomol Struct Dyn*. 2024 Feb 9:1-26.

Recently, real-world disease monitoring techniques designed based on wearable medical equipment efficiently minimize the mortality rate. Initially, the data are manually collected from the patients to predict five diseases using 5 G frameworks. Then, the collected data are pre-processed to obtain high-quality data using the techniques like contrast enhancement, median filtering, fill empty space, remove repeated value and stemming. The pre-processed data are taken for extracting the features using a One-Dimensional Convolutional Neural Network (1D-CNN) to obtain the deep features. The parameters like hidden neuron count and epoch are tuned by the proposed Modified Predator Presence Probability-based Squirrel Search-Glowworm Swarm Optimization (MPPP-SSGSO) algorithm to enhance the variance. Then, the extracted features acquired using the 1D-CNN are given to the ensemble boosting-based models for predicting the score, which is combined by comprising approaches like Adaptive Boosting (AdaBoost), eXtreme Gradient Boosting (XGBoost) and Category Boosting (CatBoost). Further, the predicted scores obtained from such models are concatenated and passed to the Ensemble Boosting Scores-based Fuzzy Classifier (EBS-FC) for classifying the five different diseases. Here, the membership function of the fuzzy is optimized by the same developed MPPP-SSGSO algorithm for enhancing accuracy. Experiments are conducted, and validation is performed, which showcased that the recommended framework achieved a better outcome rate than the

conventional techniques. Finally, the suggested strategy outperforms the current state-of-the-art methods with an accuracy rate of 91.34%.Communicated by Ramaswamy H. Sarma.

Lien vers l'article

Evaluation (Mesure des niveaux d'exposition)

Méthodes d'évaluation

Aucun article dans ce bulletin.

Evaluation population générale

Aucun article dans ce bulletin.

Risques professionnels

Aucun article dans ce bulletin.

Effets biologiques et sur la santé

In silico

Aucun article dans ce bulletin.

In vitro

Protective Properties of Botanical Extracts against 5G Radiation-induced Damage to Human Skin, as Demonstrated in Preliminary Data from a Keratinocyte Cell Culture Model.

Havas F, Cohen M, Krispin S, Attia-Vigneau J. *Front Biosci (Landmark Ed)*. 2024 Jan 19;29(1):31.

BACKGROUND: Next-generation 5G communication technology involves increasing use of 3-100 GHz wireless bands in population centers. Though still non-ionizing, this implies higher radiation energy vs. existing bands. The range is also shorter, needing more numerous emitters, closer to the user-resulting in higher electromagnetic energy exposure. With no universal consensus regarding exposure risks, there is some concern among the public and the scientific community, following indications that 5G radiation can impact immune function, trigger inflammatory responses, and influence expression of genes affecting protein folding, oxidative stress, tissue/extracellular matrix (ECM) matrix turnover, and more. This work aims at identifying botanical extracts for protection of human skin from these impacts, based on a preliminary cell culture-based model. METHODS: We irradiated human epidermal keratinocytes at 6 GHz, evaluating effects on Interleukin1-α (IL1-α), a key inflammatory cytokine; TIMP metallopeptidase inhibitor 1 (TIMP1), shown to inhibit collagenase; Angiopoietin-like protein 4 (ANGPLT4), which plays a role in wound healing and epidermal differentiation; and S100 calcium-binding protein A9 (S100A9), involved in immune recruitment during injury, by enzyme-linked immunosorbent assay (ELISA) and immunostaining. We next used this model to identify substances able to mitigate the effects of 5G irradiation, through the evaluation of the influence of treatment by one of several botanical extracts on the observed effects of 5G irradiation. RESULTS: After a remarkably short 1-h exposure, clear effects on keratinocyte function were observed: increased inflammatory cytokine IL1-α; reduced collagenase inhibitor TIMP1; increased wound healing/differentiation facilitator ANGPLT4; and increased SA100A9, involved in immune recruitment during injury. On this basis, we then showed the protective effects of selected botanical extracts, capable of reducing the increase in IL1-α induced by 5G exposure, possibly in part due to anti-inflammatory and anti-oxidant properties of compounds present in these extracts. CONCLUSIONS: Our results show a clear influence of 5G irradiation on the keratinocytes, possibly indicating injury and damage responses. What's more, we showed how these preliminary data can be used to identify botanical extracts capable of offering some protection against these effects for users of 5G technology, e.g., when employed as active ingredients in protective cosmetic applications.

Lien vers l'article

Effects of radiofrequency field from 5G communication on fecal microbiome and metabolome profiles in mice.

Wang X, Zhou G, Lin J, Qin T, Du J, Guo L, et al. *Sci Rep*. 2024 Feb 12;14(1):3571.

With the rapid development of 5G networks, the influence of the radiofrequency field (RF) generated from 5G communication equipment on human health is drawing increasing attention in public. The study aimed at assessing the effects of long-term exposure to 4.9 GHz (one of the working frequencies of 5G communication) RF field on fecal microbiome and metabolome profiles in adult male C57BL/6 mice. The animals were divided into Sham group and radiofrequency group (RF group). For RF group, the mice were whole body exposed to 4.9 GHz RF field for three weeks, 1 h/d, at average power density (PD) of 50 W/m(2). After RF exposure, the mice fecal samples were collected to detect gut microorganisms and metabolites by 16S rRNA gene sequencing and LC-MS method, respectively. The results showed that intestinal microbial compositions were altered in RF group, as evidenced by reduced microbial diversity and changed microbial community distribution. Metabolomics profiling identified 258 significantly differentially abundant metabolites in RF group, 57 of which can be classified to Kyoto Encyclopedia of Genes and Genomes (KEGG) pathways. Besides, functional correlation analysis showed that changes in gut microbiota genera were significantly correlated with changes in fecal metabolites. In summary, the results suggested that altered gut microbiota and metabolic profile are associated with 4.9 GHz radiofrequency exposure.

Lien vers l'article

Effects of 700 and 3500 MHz 5G radiofrequency exposure on developing zebrafish embryos.

Torres-Ruiz M, Suárez OJ, López V, Marina P, Sanchis A, Liste I, et al. *Sci Total Environ*. 2024 Mar 10;915:169475.

Telecommunications industries are rapidly deploying the fifth generation (5G) spectrum and there is public concern about the safety and health impacts of this type of Radio Frequency Radiation (RFR), in part because of the lack of comparable scientific evidence. In this study we have used a validated commercially available setting producing a uniform field to expose zebrafish embryos (ZFe) to unmodulated 700 and 3500 MHz frequencies. We have combined a battery of toxicity, developmental and behavioral assays to further explore potential RFR effects. Our neurobehavioral profiles include a tail coiling assay, a light/dark activity assay, two thigmotaxis anxiety assays (auditory and visual stimuli), and a startle response - habituation assay in response to auditory stimuli. ZFe were exposed for 1 and 4 h during the blastula period of development and endpoints evaluated up to 120 hours post fertilization (hpf). Our results show no effects on mortality, hatching or body length. However, we have demonstrated specific organ morphological effects, and behavioral effects in activity, anxiety-like behavior, and habituation that lasted in larvae exposed during the early embryonic period. A decrease in acetylcholinesterase activity was also observed and could explain some of the observed behavioral alterations. Interestingly, effects were more pronounced in ZFe exposed to the 700 MHz frequency, and especially for the 4 h exposure period. In addition, we have demonstrated that our exposure setup is robust, flexible with regard to frequency and power testing, and highly comparable. Future work will include exposure of ZFe to 5G modulated signals for different time periods to better understand the potential health effects of novel 5G RFR.

Lien vers l'article

Sur l'homme

Problems in evaluating the health impacts of radio frequency radiation.

Ben Ishai P, Davis D, Taylor H, Birnbaum L. *Environ Res*. 2024 Feb 15;243:115038.

In an effort to clarify the nature of causal evidence regarding the potential impacts of RFR on biological systems, this paper relies on a well-established framework for considering causation expanded from that of Bradford Hill, that combines experimental and epidemiological evidence on carcinogenesis of RFR. The Precautionary Principle, while not perfect, has been the effective lodestone for establishing public policy to guard the safety of the general public from potentially harmful materials, practices or technologies. Yet, when considering the exposure of the public to anthropogenic electromagnetic fields, especially those arising from mobile communications and their infrastructure, it seems to be ignored. The current exposure standards recommended by the Federal Communications Commission (FCC) and International Commission on Non-Ionizing Radiation Protection (ICNIRP) consider only thermal effects (tissue heating) as potentially harmful. However, there is mounting evidence of non-thermal effects of exposure to electromagnetic radiation in biological systems and human populations. We review the latest literature on in vitro and in vivo studies, on clinical studies on electromagnetic hypersensitivity, as well as the epidemiological evidence for cancer due to the action of mobile based radiation exposure. We question whether the current regulatory atmosphere truly serves the public good when considered in terms of the Precautionary Principle and the principles for deducing causation established by Bradford Hill. We conclude that there is substantial scientific evidence that RFR causes cancer, endocrinological, neurological and other adverse health effects. In light of this evidence the primary mission of public bodies, such as the FCC to protect public health has not been fulfilled. Rather, we find that industry convenience is being prioritized and thereby subjecting the public to avoidable risks.

Lien vers l'article

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