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Dejana Jovanović Popović[1]*, Ivan Samardžić, Irena Simić****

* *University of Belgrade, Faculty of Security Studies, Belgrade*
* *University of Belgrade, Faculty of Geography, Belgrade*

SMART TOURISM AND IO(N)T: POWERFUL LINK

Abstract: Smart tourism is a new catchphrase used to describe the increasing dependence of tourism destinations, industries and tourists on evolving forms of Information and Communication Technologies (ICT). The new ICT, or the Internet of Things and emerging Internet of Nano-Things is gaining enormous popularity in the world of modern wireless telecommunications that allow for massive quantities of data to be transformed into value propositions. The paper defines smart tourism, sheds light on current smart tourism trends, and then lays out its technological benefits and prospects as well as potential risks. The paper further draws attention to both international and national projects regarding smart tourism in the EU and Serbia.

Keywords: Smart tourism, Internet of Things, Internet of Nano Things

Introduction

According to the UN Tourism (formely known until 24 January 2024 as the UN World Tourism Organization – UNWTO), tourism is social, cultural and economic phenomenon which entails movement of people to countries or places outside their usual environment for personal or business/professional purposes (UN Tourism, 2025). In 2025, the estimated number of nights spent at tourist accommodation establishments in the EU reached 3.08 billion, exceeding the previous year by 61.5 million, or 2% (Eurostat, 2026). According to the World Travel & Tourism Council (WTTC) tourism is one of the EU's largest socio-economic and wealth creating activities, representing around 10.5% of the EU's gross do-

[1] dejana@fb.bg.ac.rs (corresponding author)
Dejana Jovanović Popović (https://orcid.org/0000-0002-6677-4733)
Ivan Samardžić (https://orcid.org/0000-0003-1283-8444)
Irena Simić (https://orcid.org/0009-0001-6173-605X)

mestic product (GDP) in 2025 (WTTC, 2025). The sector plays an important role in generating growth and creating jobs, but also holds huge potential – especially in the area of smart tourism. Innovation, accessibility, and sustainability are the future of tourism, and the European Commission aims to keep European tourism on the priority list and more importantly highly technologically advanced. The global smart tourism market size was calculated at USD 820.47 million in 2025 and is predicted to increase from USD 927.13 million in 2026 to approximately USD 2,785.14 million by 2035 (Zoting, 2026a).

"Smart" has become a new buzzword to describe technological, economic and social developments fuelled by technologies that rely on sensors, big data, open data, new ways of connectivity and exchange of informations (e.g., Internet of things) as well as abilities to infer and reason (Gretzel, Sigala, Xiang & Koo, 2015). The term has been added to cities (smart city) physical infrastructure (e.g., smart home, smart factory), technologies (smart phone, smart card, smart TV, etc.), or markets/economies (smart economy).

In the era characterized by unprecedented technological advancements, the digital revolution and tourism industry are extraordinarly linked. Furthermore, tourism industry was one the first sectors to embrace digital intelligence of all possible services such as smartphones, artificial intelligence, and the IoT. The growing literature on smart tourism and the increasing number of smart tourism initiatives demonstrate that the idea of smart tourism is captivating, but its concrete implementation so far has lacked the transformative focus called for by smart development principles (Gretzel, 2021).

The concept of smart tourism evolved and is frequently linked to the concept of smart cities. The core of the smart city concept is information and communication technology (ICT) (Graham & Marvin, 2001). The development of the ICT, Internet of Things (IoT) and Internet of Nano-things (IoNT) will undoubtedly have a major impact on the progress and development of all spheres of life in the future, including smart cities and tourism. Definitions that did not include sustainability as one of the strategic goals of a smart city viewed a smart city as a city that uses Information and Communication Technology (ICT) to create more interactive and efficient components and services of critical infrastructure (Azakuna, 2012). Smart cities will use communication and sensor capabilities built into the city's infrastructure, and such technologies provide space for interaction between citizens, authorities, businesses and other stakeholders, in order to actively engage in design and planning processes (Batty et al., 2012).

From a research perspective, smart tourism constitutes an inter-disciplinary field that is growing tremendously, but it is ill-defined (Bastidas-Manzano et al., 2021; Mehraliyev, Chan, Choi, Koseoglu & Law, 2020). The new ICT, or IoT is considered to be a new concept that is gaining enormous popularity in the world of modern wireless telecommunications. IoT, instead of only merging computers and people, is evolving into the unification of smart structures or things in the real world with the use of ICT (Ashton, 2009; Gubbi et al., 2013; Bresciani et al., 2018). The expansion of the IoT concept gives access to IoNT. A new communication networks paradigm so-called IoNT based on nanotechnology and IoT has the capacity to interconnect nano-scale devices through existing networks. The rapid expansion of nanotechnology and its integration with the IoT has paved the way for the IoNT, which is exponentially growing with applications in smart cities, smart agriculture, the military, healthcare, and so on. Owing to its miniaturized nature and the significant benefits that can

be expected compared to its counterpart, the IoT, the IoNT is becoming an essential part of our daily lives.

Things are more important than ideas: Internet of Things

The phrase "Internet of Things" started life as the title of a presentation at Procter & Gamble in 1999 by British technology pioneer Kevin Ashton, co-founder and executive director of the Auto-ID Center at MIT (Ashton, 2009). Ashton states that "Our economy, society and survival aren't based on ideas or information-they're based on things" (Ashton, 2009:1).

Originating in the early 2000s alongside advancements in ICT, IoT has transformed daily life by enabling everyday objects to connect to the internet. This connectivity allows for remote management and automated responses, effectively making devices "smarter." Recently, this field has expanded into the Internet of Nano-Things (IoNT), which utilizes miniature, nanoscale devices.

The Internet of Things is a revolutionary technology that is progressively gaining traction in today's wireless telecommunications environment. The IoT concept's key strength is the significant impact it will have on various elements of everyday life and on potential user behaviour (Atzori et al., 2010). IoT is rapidly playing an essential role in services, where it is undoubtedly essential for the tourism industry. IoT has evolved into a useful and practical tool for promoting evidence-based practice in tourism management. Smart tourism using IoT would attract more visitors, including a smart hotel with a smart communication system and all the fundamental necessities in a smart management system (Novera et al, 2022).

Destinations are implementing IoT sensors, smart kiosks, Near-Field Communication enabled ticketing, and location-aware services to create connected and responsive tourism ecosystems. Real-time monitoring of visitor flows helps reduce congestion, improve sustainability, and enhance the visitor experience. GPS-enabled navigation tools, automated queue management, and smart mobility services (smart parking e-scooters, autonomous shuttles) are transforming urban assessment. According to Deep Market Insights, the global urban tourism market size was valued at USD 7,800.00 million in 2024 and is projected to grow from USD 8,197.80 million in 2025 to reach USD 10,512.62 million by 2030 during the forecast period (2025–2030) (Gray, 2025a). Urban tourism market growth is primarily driven by rising global urbanization, increasing traveller preference for immersive city-based experiences, digital platform adoption, and expanding cultural, culinary, and entertainment offerings in major metropolitan areas. Museums, theme parks, and cultural sites are increasingly using IoT to track visitor engagement, personalize exhibits, and deliver interactive experiences. Governments' investments in 5G networks further accelerate this trend, enabling faster data exchange and richer mobile-based traveller interactions (Gray, 2025b).

Council of the European Union invites member states to facilitate the digital transition in tourism and support the tourism industry and sustainable management of destinations, in particular by improving the availability of comprehensive online information on the tourism offer on subjects including sustainability, accessibility and target audiences, and to promote the accessibility of tourism services to all groups with specific needs (Council of the European Union, 2022). According to the UN statistics, the number of people in the

world aged 60 years or above will grow from 1 billion in 2020 to 1.4 billion in 2030 (World Health Organization, 2025), and there are more than 650 million people with disabilities worldwide (Disabled World, 2026). Travel constraints are considered to be the main challenges facing tourists with special needs or chronic diseases who might be less motivated to travel to remote destinations due to their health concerns (Page and Hall, 2003). The Internet of Things (IoT) might provide efficient solutions that help tourists with chronic diseases. In the case of emergency, so-called Geographical Routing for Mobile Tourist might help them to find an appropriate geographical route through transportation network best served with close medical centers (Almobaideen, et al., 2017).

From Richard Feynman to Internet of Nano Things

The combination of nanotechnology and the Internet of Things has created the Internet of Nano Things (Nayyar et al., 2017). The concept of the IoNT was proposed by professor Ian F. Akyildiz and his PhD student Josep Miguel Jornet from the Georgia Institute of Technology in 2010 (Akyildiz & Jornet, 2010). They describe the Internet of Nano-Things as "The interconnection of nanoscale devices with existing communication networks and ultimately the Internet defines a new networking paradigm that is further referred to as the Internet of Nano-Things" (Akyildiz & Jornet, 2010: 58).

The main building block of IoNT is nanotechnology, i.e. nano-devices ranging in size from 1-100 nm (Drexler et al., 1993; Akhtar & Perwej, 2020). The credit for the conceptual foundation of today's nano-world belongs to Nobel Laureate in Physics Richard Feynman. At the annual meeting of the American Physical Society held on December 29, 1959, at the California Institute of Technology, Feynman gave a talk titled "There's Plenty of Room at the Bottom". In this famous lecture, he explained how scientists could control and manipulate atoms and molecules (Feynman, 1960).

The European Commission in its 2022 recommendation, revised the 2011 nanotechnology definition, and states: "Nanomaterial means a natural, incidental, or manufactured materials consisting of solid particles that are present either on their own or as constituent particles in aggregates or agglomerates, and where 50% or more of these particles in the number-based size distribution, fulfil at least one of the following conditions: one or more external dimensions of the particle are in the size range of 1 nm to 100 nm…" (European Commission, 2022: 4-5). Mihail Roco, a leader in the field of nanotechnology, identified four phases in the development of nanotechnology products. The fourth phase, the development of molecular nanosystems (2015-2020), includes intelligent design of molecular and atomic devices, leading to "unprecedented understanding and control over the fundamental building blocks of all natural and man-made things" (Roco et al., 2011). There is no doubt that Roco was right, as control and manipulation of matter at the atomic level play a very important role in shaping scientific priorities.

The global Internet of Nano Things market size is calculated at USD 26.91 billion in 2025 and is predicted to increase from USD 31.87 billion in 2026 to approximately USD 142.51 billion by 2035, expanding at a Compound Annual Growth Rate of 18.14% from 2026 to 2035 (Zoting, 2026b). North America accounted for the largest share of the IoNT market in 2025 while Asia Pacific will host the fastest-growing market during the forecast period.

Internet of Nano Things uses highly sophisticated and advanced methodologies for data collection, allowing IoNT to expand its base from existing to a wider range of new and advanced applications compared to the Internet of Things. Coordination and information exchange between nano-devices allow the formation of so-called nano-networks (Siegfried and Amangeldiyev, 2022). This opens up a completely new dimension of IoNT use and provides interaction and communication with home appliances, pollutant monitoring sensors and surveillance sensors (Table 1). Moreover, IoNT can provide much more detailed, cheaper, and up-to-date images of cities. An extraordinarily large amount of information can be collected in real time using numerous nano-sensors to improve the quality of life, health and infrastructure (Jarmakiewicz & Parobczak, 2016). These miniature sensors, interconnected via nano-networks, can pave the way for new research related to smart tourism.

Table 1. Applications of IoNT (Alabdulatif et al., 2023)

Smart cities	Implementing a smart city allows interaction and communication with home appliances and the monitoring of various aspects pertaining to the city environment through deployed smart sensors, surveillance cameras, actuators, vehicles, and various other digital devices possessed by the citizens of the city, facilitating better management of the city. As of now, smart cities have already been established with the assistance of the IoT, wherein nanosensors are used to track and identify the location of litter found in high-absorption air regions and activate nanosensors to clear that area. The IoNT has the ability to gather real-time data that may then be used to enhance public utilities, services, infrastructure, and much more in the context of a smart city.
Healthcare	Healthcare is a domain wherein IoNT solutions are highly used as of now, compared to all other domains, as we have noted through the reviewed state of the art. A Body Sensor Network (B.S.N.) is one such example. A B.S.N. employs various sensors implanted inside the human body to obtain pertinent insights and diagnostically valuable data that are otherwise outside the scope of traditional diagnostic methods... Further nanodevices could be used to monitor and track vital signs, diagnose and treat diseases, and deliver targeted therapies to specific areas of the body. For example, nanosensors could be used to detect the early stages of disease and trigger an appropriate response, such as releasing a therapeutic agent. On the other hand, the introduction of nanomedicine will lead to the development of better drugs and medical devices. It also offers different ways to improve medical diagnosis and treatment and helps in tissue and organ regeneration. Its applications also include early diagnosis of a wide range of diseases with high efficacy and personalization, which enhances patient treatment processes. Moreover, the rising demand for faster and smaller portable diagnostic sensing systems is one of the major factors driving the deployment of the IoNT in healthcare. If the IoNT makes a breakthrough in the field of healthcare, doctors will be able to monitor patients in real time instead of having to measure manually as before. As shown, enabling healthcare providers to keep a continuous eye on the patient's underlying conditions.
Environmental monitoring	In terms of environmental monitoring, nanosensors are used to monitor and track environmental conditions, such as air and water quality, soil conditions, and weather patterns. This information could be used to improve resource management, protect the environment, and mitigate the effects of climate change. In the context of a smart city, IoNT solutions are used to monitor real-time environmental conditions and generate alerts or responses according to underlying conditions.
Transportation	The IoNT is used to improve the efficiency and safety of transportation systems. For example, nanosensors are used to monitor traffic patterns and optimize routes, or to detect and prevent accidents.
Energy	The IoNT is also used to improve the efficiency and reliability of energy systems. In the context of the smart grid, nanodevices are used to monitor and optimize energy production and consumption, and to detect and prevent failures in the energy grid.

IoNT, although being in the nascent stage of research and development, has the capacity to provide highly sensitive sensors for detection of any change in concentration of dangerous gases and smoke. These miniature sensors, interconnected via nano-networks, can pave the way for new research related to fire protection Furthermore, it is expected that far more sophisticated fire detection could activate better coordinated responses from all emergency services. (Jovanovic Popovic, 2025).

The first application of IoNT in terms of health monitoring in the world today is the Body Sensor Network (BSN), which includes nano-sensors embedded in the human body that play a key role in collecting and monitoring biological activities and other details regarding the patient's health status. Nano sensors used in the human body provide real-time data to devices used by doctors to obtain timely information about the patient's health (Figure 1). IoNT is not a simple extension and continuation of traditional communication networks at the nanoscale, but a completely new level and model of communication in which communication processes are based on natural biological processes (Akhtar & Perwej, 2020).

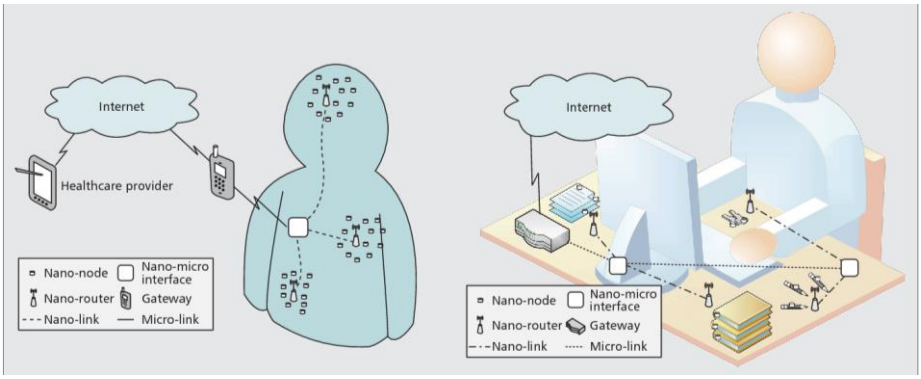

Fig. 1. Network architecture for the Internet of Nano-Things: a) Intrabody nanonetworks for healthcare applications; b) The interconnected office (Akyildiz & Jonet 2010)

The use of IoNT in smart city projects can monitor various parameters such as air and water quality in the entire city. Environmental nanosensors can provide information regarding pathogens and allergens in open or closed spaces (Balasubramaniam & Kangasharju, 2013). Nano sensors can be placed in public places such as train or bus stations, hotels, restaurants or offices and provide real-time monitoring. With IoNT, nanosensors can be used to track and identify locations of pollution detected in high concentrations in the air and trigger nanosensors to clean that specific location (Kamel Boulos & Al-Shorbaji, 2014).

Smart tourism in EU and Serbia

Under the umbrella of Smart Tourism, the European Commission launched competitions in 2019 to promote smart and sustainable tourism in ERRIN (European Regions Research and Innovation Network) member regions with populations of over 100,000. The European Capital of Smart Tourism is an EU initiative, currently financed under the Single Market Programme (SMP) – former COSME Programme. The initiative seeks to strengthen tourism-generated innovative development in European cities and their surroundings, increase their attractiveness, and foster economic growth and job creation. It also aims to establish a framework for the exchange of best practices among cities participating in the competi-

tion, create opportunities for cooperation and new partnerships. The 2026 European Capital of Smart Tourism is the seventh edition of the competition. Tampere, Finland is the winner of the 2026 European Capital of Smart Tourism (European Commission, 2026). Tampere is and is committed to become carbon neutral by 2030, leading the way in smart solutions for climate change mitigation. Previous winners include Torino (2025), Dublin (2024), Pafos and Seville (2023), Bordeaux and Vale`ncia (2022), Gothenburg and Ma´laga (2020), Helsinki and Lyon (2019).

On the other hand, in Serbia, there are also noteworthy initiatives regarding the smart tourism. The Tourist Organization of Sokobanja is planning a significant step forward in the digital presentation of the destination and introduction of modern AI solutions, with the aim of making Sokobanja the first truly "smart" tourist destination in Serbia (Stojanović, 2026). Further, the Provincial Secretariat for Economy and Tourism of the Autonomous Province of Vojvodina is implementing the project entitled “Smart Tourism: The joint future of the Pannonian region” (2024 -2026) within the Interreg VI-A IPA Hungary-Serbia program aiming to modernize and sustainably develop tourism through application of modern digital technologies and AI. The project enhances the visibility and accessibility of cultural and natural assets while supporting eco-friendly tourism. The project is being implemented in cooperation with the Serbian Provincial Secretariat for Economy and Tourism as lead partner, and Faculty of Economics in Subotica, University of Novi Sad and the Euroregional Development Agency Danube-Kris-Mures-Tisa (DKMT) from Hungary. The program covers the Hungarian counties of Csongrád-Csanád and Bács-Kiskun, as well as the territories in Serbia - West and North Bačka, South Bačka District, North Banat, Central Banat, South Banat District and Srem (European Union, n.d.).

Risks and Security issues

It is believed that both IoT and the emerging IoNT offer limitless benefits but that it is faced with certain challenges. That need to be resolved so as to ensure that in the near future IoT and IoNT are of great usage for people, without any limitations. In everyday life, there are risks of the IoNT, in objects such as the telephone, appliances, sensors, vehicles, infrastructure systems, and there are digitised control and monitoring procedures that are connected onto the Internet, which raises a number of issues regarding security and privacy.

Applications of the IoNT in medicine stands for a very significant improvement of human health in new ways, especially in terms of prevention, proactive monitoring, management of chronic diseases, etc. One of the biggest challenges of IoNT development is data security, referring to data that are transmitted via the Internet, such as health-related data. Nano and micro sensor networks allow continuous monitoring of health and registering the patients' vital parameters, and also transmit sensitive data to a centralised location, where properly trained staff can monitor and process them. Since e-Health systems store and process very sensitive data, such systems should have the suitable framework and security and privacy mechanisms in place (Omanovic´-Miklic˘anin *et al.*, 2015). Health-related data must be protected against unauthorised access, which may have serious consequences on people. Therefore, challenges related to privacy must be resolved in order to resolve appropriate handling of sensitive data collected through devices that are used for personal health monitoring.

It is expected that IoNT devices will potentially have an invasive impact on the human body in terms of healthcare or tourist with chronic diseases. Naturally, this raises multiple

security and ethical issues, as well as privacy issues that need to be resolved so as to diminish public concerns and protect sensitive data collected through nanosensors (Miraz, 2018). Therefore, data security measures must be applied in 4G and 5G networks, in particular in the IoNT, which is vulnerable to all types of attacks given the fact that devices are not continuously monitored (Akhtar & Perwej, 2020).

Attacks may take the form of a theft of sensors, interference with the use of computers or change in nanonetwork communication connections since standard security techniques cannot be applied to nanonetworks, since they are based on terahertz waves. The use of networks for the purpose of collecting private and personal data makes these networks appealing to potential attackers. Hence, it is necessary to introduce new security techniques so as to ensure the protection of sensitive data collected through nanosensors.

Conclusion

Digital transformation is no longer a matter of choice, but many believe of survival of the global tourism industry. For a modern tourist, the right information at the right moment is of paramount importance. Smart tourism solutions are becoming core components of smart city and tourism initiatives, integrating real-time mobility data, sensors, and visitor analytics to optimize traveler flow and enhance safety. Nanotechnology can enhance performance and functionalities of IoT devices by creating the design of smaller, more efficient, and diverse sensors, antennae, and processors. These enhancements result in higher precision, energy efficiency, and diversity of applications, including the use of nanosensors for monitoring human health, industrial monitoring, as well as pollutant monitoring, both indoors and outdoors.

Nevertheless, the magic of IoT and IoNT in the tourism sector, such as smart applications, smart services and smart management can also turn into a curse if smart applications, data security or the data infrastructure are not used properly or are not user-friendly. Potential use of IoNT technology may give rise to concerns due to lack of regulation thus potentially giving rise to significant security and privacy concerns. Furthermore, smart tourism practically means that the experience of a tourist depends on whether the tourist uses smart devices that can run various applications. The next question regarding the intelligent travel system is the position of tourists who do not have appropriate smart devices, or those who want to enjoy their travel without smart gagets or elderly without sufficient knowledge or skills to be on friendly terms with smart devices.

Nevertheless, there are challenges and limitations regarding the use of IoT and IoNT, including ethical issues, the issues of privacy, and security protection. In order to overcome these challenges, it is necessary to continue research and strategy development. Convergence of nanotechnology and the Internet of things holds high expectations for the future. It is realistic to expect that the two technologies and their applications in smart tourism will continue to develop in the years to come.

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