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Study Regarding the Intention to Use 6G Technology: Evidence from Romania

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Abstract. *Even though 6G is still under development, many authors are analyzing the key characteristics of this new technology that is expected to offer improvements, capabilities and other new opportunities compared to the actual technology. Discussing the contribution of this study, it will complete the specialized literature with a presentation of the theoretical concepts related to the evolution of the cellular network architecture, the main topics of 6G, the development of a research model that will study the intention to use, the development of the hypotheses based on literature review and testing them with SPSS tool. Based on the research analysis, security and privacy were mentioned as key topics for 6G development, they were presented from the technology perspective with focus on the concept and from customer's perspective as how they perceive these concepts while deciding to use a new technology. The research model was developed based on research analysis of studies that have discussed the key topics that are relevant for the 6G development as security and privacy and there were selected perceived usefulness, perceived ease of use, attitude and behavioral intention to use 6G to determine the perception of the respondents that took part of the survey. The data was collected though an online questionnaire and using SPSS tool, there were performed KMO, reliability test, correlation analysis and bivariate regression for the hypotheses testing.*

Keywords: 6G, mobile telecommunication services, telecommunication company, wireless communication, technology acceptance, security, privacy.

Introduction

Once new technology will be released, a high demand of security capabilities will be needed, as well as the assurance that the requested capabilities are already in place and 6G networks have the responsibility to provide assurance to the users and to the operators, in the deployment and during the operation phases under the form of security awareness and resilience. In the connected society, these 6G security capabilities will be required to respect the privacy and the personal data ownership and at the same time must respect the user's preferences and expectations (https://www.ericsson.com/en/6g). Understanding the needs and the preferences while people accept or reject a new technology is considered a relevant topic in the context where technology use has produced several beneficial results in different domains of activity (Shah, 2022).

This study is structured as follows: in the literature review is presented the evolution of cellular network architectures from 1G to 6G, highlighting the key aspects of 6G, the main challenge area for development, issues related to security and privacy and hypotheses development section where based on the research analysis were defined five hypotheses that have an impact on the intention to use a new technology. The methodology section contains the research model used in this paper, profile of the respondents that took part of the questionnaire, presentation of the

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chosen variables and the items, while in the results and discussion section are presented the obtained values using SPSS tool as: test of sphericity, Cronbach's Alpha's values, correlation analysis and bivariate regression coefficients.

Literature review

1.1 Evolution of cellular network architecture and 6G technology

Starting with the evolution of cellular network architecture according to (Shah, 2022), the first generation is known as advanced mobile phone services (AMPS), the mobile cellular system was built to accommodate voice communications for mobile users, while in the second generation, the capacity of voice users was increased, providing integrated data services and by replacing previous technology it was improved voice communications via the use of voice coders (vocoders), data services, originally through SMS, security encryption, and enhanced system capacity. In the third generation, digital cellular technology was developed to expand subscriber capacity and support higher data speeds, to facilitate internet access while the customers were receiving phone and data services and it was facilitated the introduction of video applications on mobile devices (Shah, 2022). All the characteristics of each generation are presented in the Figure 1.

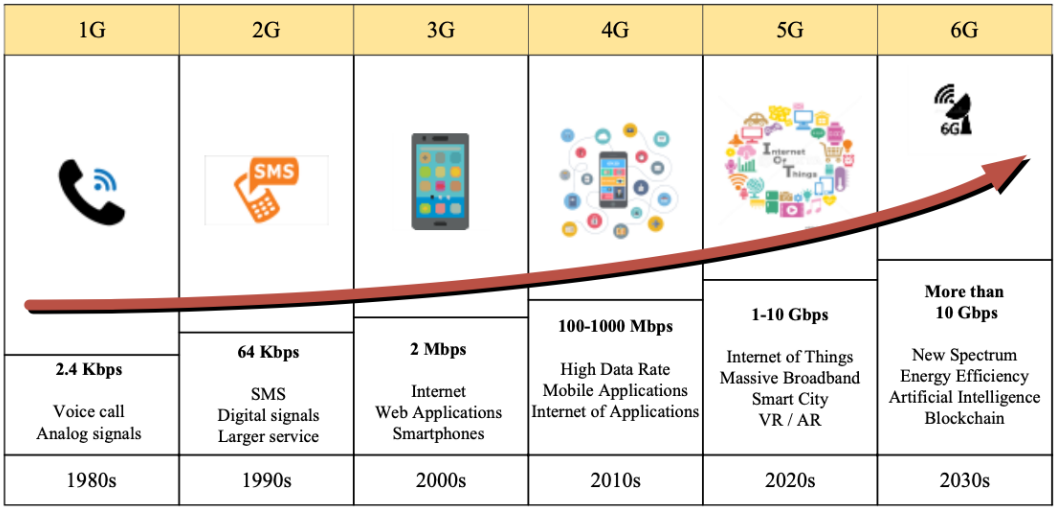

Figure 1. The evolution of cellular communication

Source: Shah et al. (2021). Survey and performance evaluation of multiple access schemes for next-generation wireless communication, *IEEE Access*, *9*, 113428-113442.

The fourth-generation digital cellular technology was developed, especially for mobile internet and video applications and it was improved system capacity, speed, latency, and user experience (Shah, 2021; Elnashar et al, 2016), while fifth generation offers: higher device density per square kilometer, lower latency, greater system capacity, more flexible bandwidth deployments, improved energy efficiency (Shah, 2022).

Being analyzed the characteristics of 5G vs 6G, (Singh et al, 2023) concluded that speed and capacity will be improved as for 6G is expected to reach tens of GBT per second or beyond, latency will be reduces and will enable ultra-responsive applications such as remote surgery and autonomous vehicles, in the spectrum utilization, 6G is expected higher frequencies, increasing capacity, energy efficiency will be given top priority which will help battery-powered products and enhance environmental sustainability and AI, that is predicted to be integrated in intelligent network management, adaptive resource allocation and enhanced security which will facilitate

more efficient and reliable networks, supported by (Wang et al, 2023). The main challenge area for 6G are presented in Figure 2.

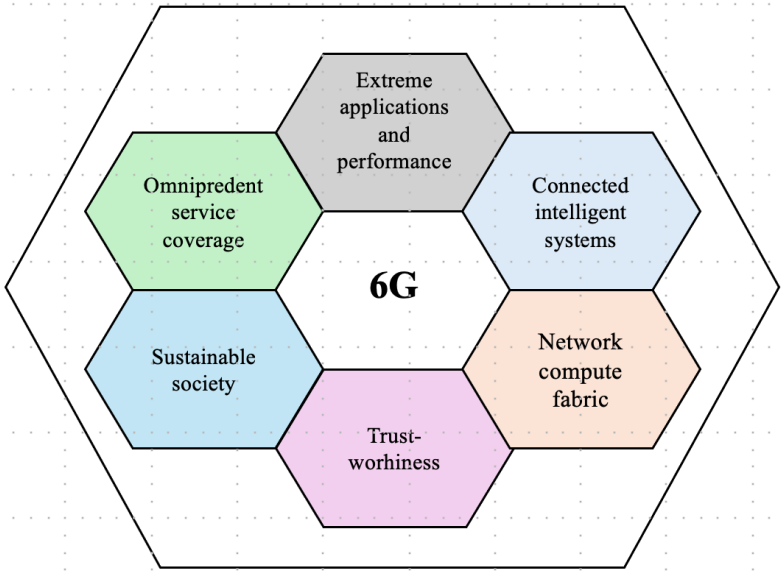

Figure 2. Main challenge areas for 6G
Source: adapted from Wikström et al. (2020, March). Challenges and technologies for 6G. *2nd 6G wireless summit (6G SUMMIT)* (pp. 1-5). IEEE.

Sustainable society is focused on the economic transformation and achieving the sustainable goals concentrated on energy efficiency and carbon reduction and will drive innovations in agriculture, transportation, environment monitoring, education, governance and law enforcement. Trustworthiness is focused on enhanced security and must create and meet stricter regulations, resilience and predictability in building resilient network that can isolate all the threats that could appear and user privacy and integrity in providing capable tools that can protect personal data and ensuring that the communication process is secure (Wikström et al, 2020).

Omnipresent service coverage is focused on connecting everywhere as lands, air, sea while will require integration of land, air and space-based networks that will form a unified network where all the devices and users are connected. Extreme applications and performance are focused on the KPIs improvement as latency, throughput, range, power consumption while it's expected applications with new capabilities in entertainment, e-health, industry and agriculture, transportation, governance and law enforcement. Connected intelligent systems are focused on the integration of AI and machine learning into 6G networks as AI and mobile devices, smart society integration with smart cities, and traffic systems. Network compute fabric is focused on supporting applications with improved KPIs, flexible deployment and optimization that will ensure a better quality of experience and improving the performance of new applications (Wikström et al, 2020).

Being identified in the Figure 3, the most important requirement areas that should be met in 6G, latency and data rated are considered key parameters for services, coverage and total cost of ownership are considered key for 6G ecosystems, while protection and hardness are the key for trust and power consumption and sustainability present the importance of a new technology (Wikström et al, 2020).

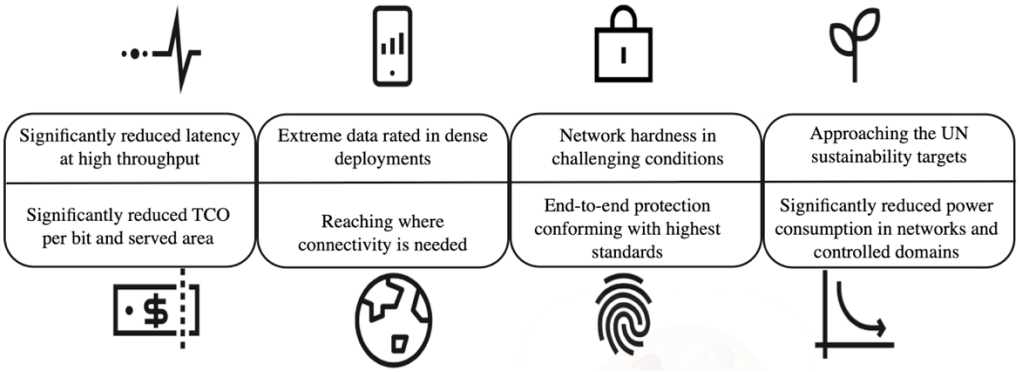

Figure. 3. Some of the main requirement areas to consider for 6G

Source: adapted from Wikström et al. (2020). Challenges and technologies for 6G. *2nd 6G wireless summit (6G SUMMIT)* (pp. 1-5). IEEE.

Being highlighted by (Wikström et al, 2020) that security and privacy were part of trustworthiness as one of the main challenge areas in 6G development, Figure 4. presents possible attacks on different layers of the 6G architecture.

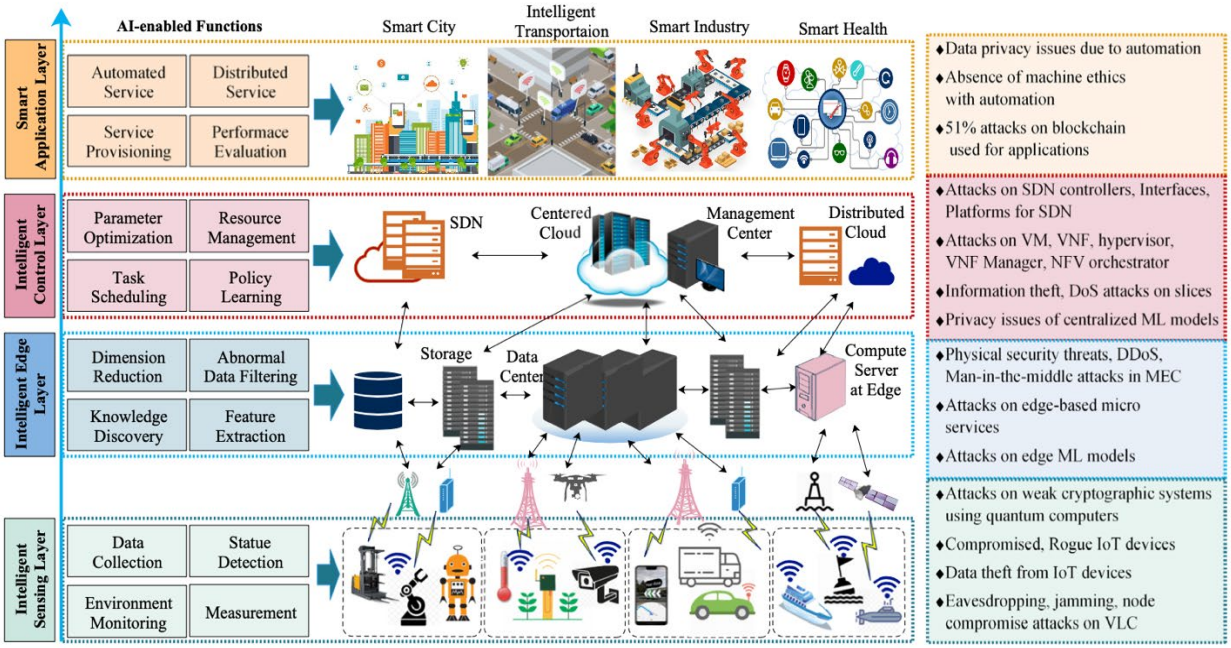

Figure 4. Intelligent 6G Architecture and Security & Privacy Issues

Source: Siriwardhana et al. (2021). AI and 6G security: Opportunities and challenges. *Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit)* (pp. 616-621). IEEE.

1.2 Hypotheses development

According to (Akbari et al, 2019) understanding the rejection or the acceptance of a new technologies is considered controversial in the ITC or the technology field, while the positive effects of the technology use can be seen in many domains and it's considered crucial to evaluate the customers' opinion and their attitude or reasons to accept new technologies. Perceived Usefulness (PU) and perceived ease of use (PEoU) are considered opinions of the new things that can affect a person's attitude toward the acceptance of the new technology and at the same time as

the most influential variables that can impact the acceptance or adoption of a new technology (Akbari et al, 2019).

(Al-Maroof et al, 2021) supports the topic, while PU and PEoU are considered core determinants of attitude towards behavioral intention, which means that the intention of use or adopt new technology is affected by the user's attitudes on the ease of use and usefulness. PEoU is considered the principal element that can support the adoption or the acceptance of the new technology while creates more expansive PU and at the same time, PEoU both directly and indirectly affects the intention to use of the customers and this variable occasionally indirectly affects the intention through PU, while PU directly influences the intention of user's behavior toward the adoption of the new technology (Akbari et al, 2019). Based on these arguments, can be hypothesized as:

H_1. PU has a positive impact on the intention to use 6G.

H_2. PEoU has a positive impact on the intention to use 6G.

According to (Al-Maroof et al, 2021) the intention of using a new technology can be influenced by the attitude of the users, while according to (Cologna et al, 2024) attitudes in a general discussion are thought of as more or less constant personal characteristics that effectively explain past behavior and forecast future behavior. It's known that attitudes toward technology, such as the adoption or acceptance of various technologies and associated behaviors, are influenced by perceptions of the risks and benefits of those technologies (Cologna et al, 2024). Based on these arguments, it will be hypothesized as follows:

H_3. User's attitude has a positive impact on the intention to use 6G.

Expecting to be released in the 2030s with new capabilities, new technology will require new standards or levels of security, cyber-resilience, privacy, trust which will raise challenges that must be proactively addressed and resolved. With the expansion of billions of devices and sensors subnetworks, it will increase the number of the threats and will essential the development of a set of 6G-era security technology enablers that are supported by AI or Machine Learning, as well as principles of cyber resilience. Privacy will become crucial as a big amount of data will be generated, stored and processed by the 6G network and its services. Increasing the number of the complex fraud, blackmail schemes or other methods of data leakage could be a target for the untrustworthy companies that can use the data and, in this way, commercial data confidentiality will become essential for the next generation of network, as development of new technologies for the anonymization and privacy protection that balance a low level of data exposure with valid analytics will be necessary. New network capabilities and new applications will be made possible by 6G, which will encourage global cooperation but at the same time, those networks and applications will never be adopted by organizations, industries, or consumers, unless they feel confident that they are safe, private, and reliable (https://d1p0gxnqcu0lvz.cloudfront.net/documents/Nokia_Bell_Labs_Envisioning_a_6G_future_eBook_EN.pdf).

Perceived privacy is defined as "a person's self-assessed state in which access to his or her information by an outside agent is limited" and at the same time as "the possibility that users' data were collected and that data was not used appropriately by online companies" (Zhang et al, 2024).

Perceived security is defined as "the level of trust a user has in the security of a specific service" according to (Park & Kim, 2013), while according to (Zhang et al, 2024) perceived security is described as "a threat, i.e., destruction, disclosure, data modification, denial of service and/or fraud, waste, and abuse" and has the scope to protect users or customers from personal and economic risks using developed technologies.

Security and privacy were mentioned as one of the main challenge areas in 6G development by (Wikström et al, 2020) and (Siriwardhana et al, 2021), these ones were presented from developers' and customer's perspective and it will be hypothesized as:

H_4. User's security has a positive impact on the intention to use 6G technology.

H_5. User's privacy has a positive impact on the intention to use 6G technology.

Methodology

This research used a quantitative method, an exploratory study as a questionnaire that was online distributed to the respondents, while containing six dimensions that were designed to determine the intention to use 6G.

In Table 1 is presented the profile of the respondents included in the sample.

Table 1. Profile of the respondents

Profile of the respondents	Female	Male	Grand Total
Rural	2	1	3
Yes	2	1	3
25 - 34	2		2
Doctoral Degree	1		1
Master's Degree	1		1
35 - 44		1	1
Bachelor's Degree		1	1
Urban	30	21	51
No	11	2	13
25 - 34	9	2	11
Bachelor's Degree	1	2	3
Doctoral Degree	1		1
Master's Degree	7		7
35 - 44	2		2
Bachelor's Degree	1		1
Master's Degree	1		1
Yes	19	19	38
18 - 24	4		4
Bachelor's Degree	3		3
Master's Degree	1		1
25 - 34	11	12	23
Bachelor's Degree	1	6	7
Doctoral Degree	1		1
Master's Degree	9	6	15
35 - 44	3	6	9
Bachelor's Degree		2	2
Doctoral Degree		1	1
Master's Degree	3	3	6
45 - 54	1	1	2
Master's Degree	1	1	2
Grand Total	32	22	54

Source: Authors' own contribution.

The questionnaire contains five demographic questions presented in Table 1 and twenty-three questions with a five-point Likert scale presented in Table 2.

Table 2. Variables of the research model

Variable	Item code	Item	Item source
Perceived Usefulness	PU_1	Using 6G technology will improve my performance and effectiveness at my job.	Adapted from (Akbari et al, 2020)
	PU_2	Using 6G technology will have more advantages than disadvantages.	
	PU_3	Compared the other technologies, the 6G technology will be more beneficial.	
	PU_4	Using 6G services would enhance my effectiveness to extend my communication.	
Perceived Ease of Use	$PEoU_1$	Compared with the other technologies, learning to operate the 6G will be easier.	
	$PEoU_2$	Overall, I would find the 6G technology easy to use.	
	$PEoU_3$	It would be easy for me to become skillful in the use of the 6G services.	
	$PEoU_4$	Using the 6G services would not require a lot of mental effort.	
Behavioral Intention to Use	BI_1	I intend to accept the 6G services in the next 12 months after the release date.	
	BI_2	I predict I would accept the 6G services in the next 12 months after the release date.	
	BI_3	I plan to use the 6G services in the next 12 months after the release date.	
	BI_4	I would be one of the first people that use 6G services after the release date.	
Security	S_1	Operators will invest in a comprehensive set of security technology enablers for the 6G era.	Adapted from (Nokia Bell Labs Envisioning a 6G Future, 2024) and (Akbari et al, 2020)
	S_2	6G will bring new secure capabilities.	
	S_3	I perceive the information related to the use of 6G technology as secure.	
	S_4	I consider that the parties will not be able see the information I provide while using 6G technology.	
Privacy	P_1	6G providers will be able to ensure the confidentiality of the customer data.	Adapted from (www.fortinet.com)
	P_2	6G providers will be able to ensure the integrity of the customer data.	
	P_3	6G providers will be able to ensure the availability of the customer data.	
Attitude (AT)	AT_1	I think 6G technology will be used to perform my job tasks.	Adapted from (Cologna et al, 2024)
	AT_2	I found 6G technology helpful to be used in my free time.	
	AT_3	I found a positive influence in using 6G services at work.	
	AT_4	I found a positive influence in using 6G services in my free time.	

Source: Authors' own contribution.

In Figure 5 it's presented the research model.

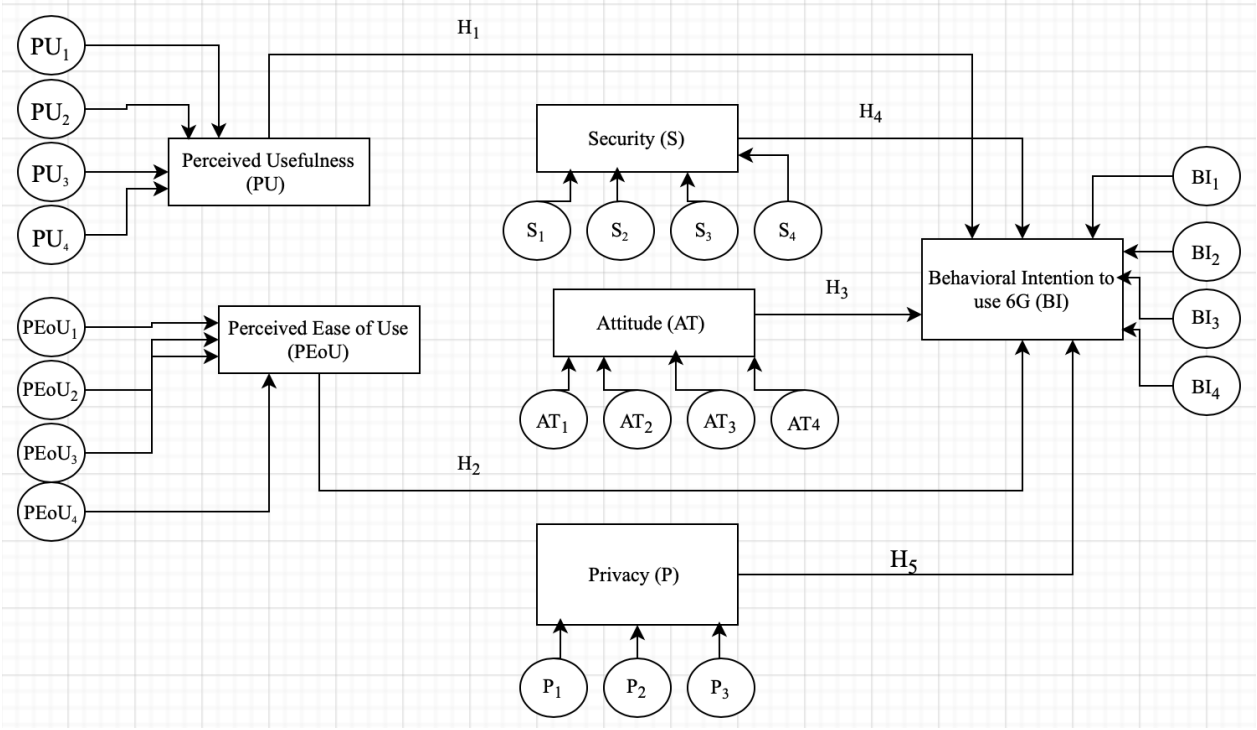

Figure 5. Research model

Source: Authors' own contribution.

Results and discussions

Being collected through an online questionnaire, the statistical analysis was performed using the SPSS tool, where in Table 3 is presented the obtained values for KMO and test of sphericity.

Table 3. KMO and test of sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.879
Bartlett's Test of Sphericity	Approx. Chi-Square	1373.739
	df	253
	Sig.	.000

Source: Authors' own contribution based on SPSS results.

According to the theory, KMO measures the sampling suitability, which means if the responses given with the sample are adequate or not, being recommended a value of 0,5 as minimum (barely accepted), while the obtained values for this research model from 0,8 to 0,9 are considered meritorious according to (Hair et al, 2019). To test the reliability among the variables, the values obtained for Cronbach's Alpha are presented in Table 4.

Table 4. Reliability statistics for the constructs of the study

Variable	Cronbach's Alpha (α)
Perceived Usefulness (PU)	0,910
Perceived Ease of Use (PEoU)	0,812
Attitude (AT)	0,892
Behavioral Intention of Use (BI	0,918
Security (S)	0,925
Privacy (P)	0,936

Source: Authors' own contribution based on SPSS results.

Based on the values obtained for Cronbach's Alpha can be concluded that the reliability among the items is consistent and was obtained a good strength of association for the values between 0,8 and 0,9, while for the values between 0,9 and 0,95 was obtained an excellent strength of association according to (Hair et al, 2019).

Table 5 contains the correlation among the variables of the research model.

Table 5. Correlations among the variables

		PU	PEoU	AT	BI	S	P
PU	Pearson Correlation	1	.760**	.831**	.740**	.805**	.713**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	54	54	54	54	54	54
PEoU	Pearson Correlation	.760**	1	.773**	.753**	.643**	.656**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	54	54	54	54	54	54
AT	Pearson Correlation	.831**	.773**	1	.678**	.723**	.705**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	54	54	54	54	54	54
BI	Pearson Correlation	.740**	.753**	.678**	1	.748**	.692**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	54	54	54	54	54	54
S	Pearson Correlation	.805**	.643**	.723**	.748**	1	.826**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	54	54	54	54	54	54
P	Pearson Correlation	.713**	.656**	.705**	.692**	.826**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	54	54	54	54	54	54

Source: Authors' own contribution based on SPSS results.

Overall, it can be concluded that there is a significant correlation at $p< 0,01$ level among the variables of the research model. The highest correlation coefficient as $r=0,831$ was obtained

between attitude and perceived usefulness, the next correlation coefficient as r=0,826 between security and privacy. The next one as r=0,805 was obtained between security and perceived usefulness and the next value for the correlation coefficient as r= 0,773 was obtained between attitude and perceived ease of use. It was performed a bivariate regression for hypothesis testing where the dependent variable is Behavioral Intention to use 6G and the dimensions of the research model are the predictors. Table 6 contains the model summary results of the bivariate regression.

Table 6. Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.832[a]	.691	.659	.53852

a. Predictors: (Constant), P, PEoU, PU, AT, S

Source: Authors' own contribution based on SPSS results.

R Square according to (Hair et al, 2019) shows the amount of variation in one variable that is accounted for by another variable, where in this case there is 69,1% variance of the independent variable and the behavioral intention to use 6G is explained by the independent variables. A larger R Square indicates a stronger relationship between the independent variables and the dependent measure according to (Hair et al, 2019), while the Table 7 contains the ANOVA results.

Table 7. Anova Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	31.200	5	6.240	21.517	.000[b]
	Residual	13.920	48	.290		
	Total	45.120	53			

a. Dependent Variable: BI

b. Predictors: (Constant), P, PEoU, PU, AT, S

Source: Authors' own contribution based on SPSS results.

The F ratio is the result of comparing the amount of explained variance to the unexplained variance according to (Hair et al, 2019) where in this case F ratio has a value of 21.517 and can be concluded that it's a strong relationship between the Behavioral Intention to Use 6G and the dimensions of the research because it was obtained a significant value. Regression coefficients show how much of the variance in the dependent variable is explained by the independent variable according to (Hair et al, 2019) that are presented in the Table 8.

Table 8. Bivariate regression results

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.397	.370		1.072	.289
	PU	.140	.175	.142	.801	.427
	PEoU	.460	.145	.434	3.183	.003
	AT	-.073	.140	-.084	-.521	.605
	S	.317	.151	.358	2.100	.041
	P	.061	.132	.070	.465	.644

a. Dependent Variable: BI

Source: Authors' own contribution based on SPSS results.

According to (Hair et al, 2019) the hypotheses of the model will be considered supported or not based on the values obtained in the bivariate regression, where the Sig. value for each variable must be lower than 0,05. There were obtained values lower than 0,05 for Perceived Ease of Use and for Security, while the hypotheses for Perceived Usefulness, Attitude and Privacy were not supported.

The first hypothesis is H1. *PU has a positive impact on the intention to use* 6G has not been supported. Discussing a new technology that will be released based on the other research papers in 2030, this hypothesis has not been supported since the technology is maybe unclear for the respondents, as now it's under the development and maybe they are skeptical to have a clear opinion about the usefulness and the utility to use or to integrate in their day-to-day activities.

The second hypothesis is H2. *PEoU has a positive impact on the intention to use 6G* has been supported and can be concluded that respondents were comfortable to learn new things and the continuously development of new skills or a new technology, as they consider that comparing to the other technology, learning to operate will be easier, it will be easy to become skillful in the use of the new technology and using the new one would not require a lot of mental effort.

The third hypothesis is H3. *User's attitude has a positive impact on the intention to use 6G* has not been supported. According to (Cologna et al, 2024) attitudes in a general discussion are thought of as more or less constant personal characteristics that effectively explain past behavior and forecast future behavior and at the same time is known that attitudes toward technology, as the adoption or acceptance of various technologies and associated behaviors influenced by perceptions of the risks and benefits of those technologies. The obtained results were generated on the respondent's beliefs in using a new technology that is still under the development, where are involved their personal beliefs about the efficiently and the expected capabilities of 6G technology, while at the same time involves user's tendency to understand clear, take and to assume the risks they are exposed to.

The fourth hypothesis as H_4. *User's security has a positive impact on the intention to use 6G technology*, where respondents can consider the security as a top priority while decide to start using a new technology. According to (https://www.itu.int/itudoc/itu-t/85097.pdf) the requirements for a generic framework are: „Customers/subscribers need confidence in the network and the services offered, including availability of services (especially emergency services) in case of major catastrophes (including terrorist actions); Public authorities demand security by directives and legislation, in order to ensure availability of services, fair competition and privacy protection;

Network operators and service providers themselves need security to safeguard their operation and business interests, and to meet their obligations to the customers and the public operations and business interests, as well as to fulfill their duties to the public and customers". As explained by the requirements developed by ITU, security plays a critical role for both parties involved in the process of 6G development by network operators and service providers that are responsible to deliver the services to their customers by using and developing capable tools in order to protect their customer's data, while customers are looking for trust created from measures, solutions and safe products and services when they are using it or accessing the applications developed based on 6G technology.

The fifth hypothesis is H5. *User's privacy has a positive impact on the intention to use 6G technology* has not been supported.

According to (https://www.fortinet.com/resources/cyberglossary/cia-triad), confidentiality involved the efforts done by the organization to maintain the customer data as private, integrity involves maintaining the customer data trustworthy, this could be possible only if the data is authentic, accurate and reliable. Even though, confidentiality and integrity of the data is maintained, the customer data must be available to the parties involved in the process as organization's employees or to the customers that serve, otherwise, if customer data is not available to the authorized parties, it's considered useless and this is possible only if the applications, networks, and systems must be operating at the appropriate times and in the appropriate manner. Being a sensitive topic nowadays, privacy plays a critical role while respondents can present their reticence using a new technology that is still in the development stage.

Conclusion

The aim of this study was to present a short evolution of the cellular network architecture, with the focus on the next technology and key aspects highlighted by other researchers about the capabilities and the requirements that must be met with the release date, while it was developed a research model that contains six dimensions that determine the intention to use 6G, where the hypotheses were tested.

The contribution of this paper is divided into two levels: as the theoretical level, where this research will complete the set of the papers or the research picture that are discussing the theoretical impact of the new technology with the focus on the possible utilization of this one, through the applications and services developed based on 6G, that is expected to bring new capabilities, improvements and new opportunities. The practical level is focused on the customer's concerns, expectations and key points that affect at the same time their intention to use or to adopt the new applications, services or products that will be developed based on 6G, highlighted by the results obtained from questionnaire and are critical to be determined for the network operators and service providers, as customers' decisions to use or to adopt is strictly related to the ability of the developers to build trust in the developed products or services based on 6G technology.

Being expected to provide new capabilities, opportunities and improvement with 6G development, the risks are also expected by the customers where focus was on security and privacy based on the research analysis. As the limitations of this study, the results were obtained based on the responses given by the respondents that took part of the survey. Being a technology that it's still under development and it's expected to be released in 2030, the respondents may have reticence to determine how useful this new technology and the results of this study cannot be generated. Future research will be focused on the analysis of all the factors that could affect the intention to use 6G, using a higher sample with an increased number of respondents.

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