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Analysis of eSIM technologies and Wi-Fi offloading algorithms

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Importance Nowadays embedded SIM (eSIM) become more popular technology and it aims to overcome the traditions plastic SIM cards, while it is actual technical implementation was developed many years ago. Also data traffic over cellular networks shows the current exponential growth, which is increasing annually by an order of magnitude and has already exceeded voice traffic. This increase in the need for information traffic leads to the fact that light-emitting diodes need solutions to enhance the provision of capabilities, as a result of which offloading traffic to Wi-Fi is one of the ways to increase full capabilities. Despite the fact that offloading on Wi-Fi networks has matured over the years, operators face various problems in realizing this task.

Objectives In this article, we will talk about the meaningful problems when offloading information traffic on a Wi-Fi network. Also, we will investigate eSIM technology, it's processes and its use in practical aspects. How this virtual SIM card technology is used nowadays and in which variations and implementations we can meet it.

Methods The research involves the methods of logical and comparative analysis.

Results Offloading mobile data is expected to become a key industry segment in the near future due to the unprecedented growth rate of data traffic on mobile networks. Wi-Fi offloading has evolved into a mature offloading solution. Most carriers around the world have begun deploying Wi-Fi offload solutions. However, there are a number of problems that must be correctly addressed in order to create a successful unloading mechanism. Key issues include spatial and temporal estimates for unloading, planning and deployment issues, choice of backhaul, device limitations, and charging mechanisms. Such problems can be properly addressed by the joint efforts of all participants in the value chain of mobile data transmission. We can see that there are a high variety of virtual SIM technologies used in different implementations, which are somehow differ in implementation of provisioning and storing SIM profile. During the analysis of virtual SIM technologies it was find out that the most popular and secure for nowadays are eSIM technology for provisioning SIM profiles OTA that was set a new standard related to embedded Subscribed Identity Module. Future work enclosed in the developing of personal router that works on eSIM technology and developing personal algorithm for Wi-Fi offloading to seamless switching between cellular data and Wi-Fi.

Keywords: Wi-Fi offloading, embedded SIM, data traffic, mobile data

Intoduction

The number of smartphone subscription connections at the global level has reached three billion, and within the last 5 years, data traffic has increased over 40-fold. According to a Cisco report [1], smartphone-based data traffic is predicted to exceed eightieth of total knowledge traffic generated on mobile networks by 2020.

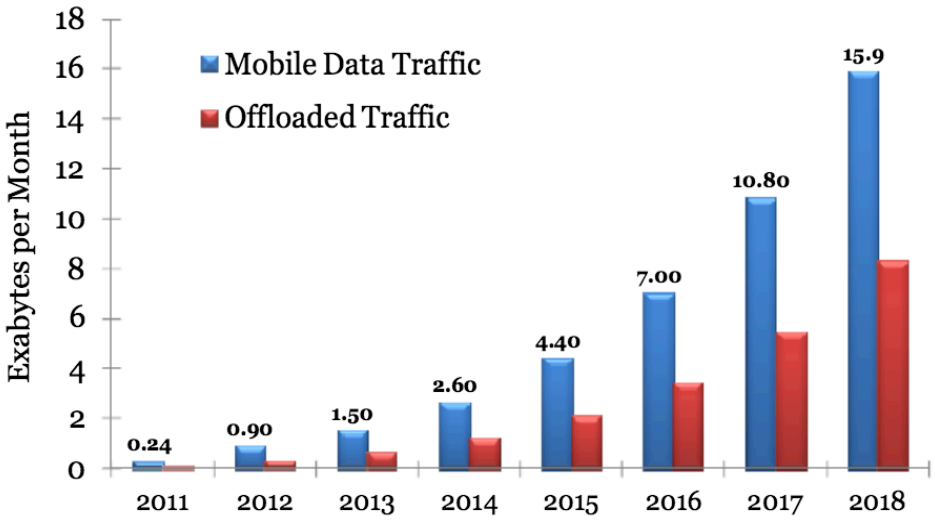

Figure 1 – Global mobile data traffic along with current and predicted offloaded data [1]

This unexampled growth of data traffic may be attributed to variety of things. The widespread adoption of Machine-to-Machine (M2M) [2] technologies across a variety of industries is another conducive issue. Wi-Fi offloading technology transfers part of the cellular network load to Wi-Fi network via the Wi-Fi access points. Network suppliers are searching for methods that specifically offload the cellular data traffic into Wi-Fi (IEEE 802.11) systems to adjust the heap and improve organize execution. A few designs dependent on Proxy Mobile IPv6 (PMIPv6) have been proposed to support seamless mobile data offloading. According to the article "Cellular Meets WiFi: Traffic Offloading or Resource Sharing"[3] traffic offloading and resource sharing are two common methods for delivering cellular data traffic over unlicensed bands. Author in [4] describes SIM evaluation and over the years, the device of physical SIM cards has not changed much. Of course, they decreased in size: Mini-SIM 25 x 15 mm, Micro-SIM 15 x 12 mm, Nano-SIM 12.3 x 8.8 mm. However, SIM cards retained functionality and compatibility, regardless of format. And you still need to insert a small plastic card into your phone or tablet to connect to the mobile network. Every cubic millimeter of a smartphone matters when you try to create increasingly complex electronics. At first they abandoned the 3.5 mm audio jack, now the relative large SIM card to manufacturers seems an anachronism. Phones without SIM cards have existed for a long time - they were used in DAMPS and CDMA-800 networks. However, such devices were tied to the communication standard: it was impossible to change the number or connect to another operator, simply by inserting another SIM-card into your phone. GSM phones without a SIM slot were introduced several years ago. Connecting such devices to mobile communications is carried out without buying an embedded card - the operator and tariff are selected in the device settings. The SIM card in the form of a chip is sealed into the device at the stage of its manufacture. The advantages of such a solution are obvious: when traveling, it's much easier to switch to the local operator's network, the problem with different sizes of SIM cards disappears, and even free up space for new smartphone functions. Samsung Gear S2 3G was the first device supporting eSIM (Embedded SIM), however, the technology gained wide popularity after the release of Apple Watch Series 3 (sales of the new model of Apple watches were twice as high as Series 2). Apple's solution could not do without interesting features: eSIM in Watch 3 works only with the iPhone - while the iPhone and Apple Watch must connect to the same mobile operator. Embedded SIM (eSIM) become more popular technology and it aims to overcome the traditions plastic SIM cards, while it is actual technical implementation was developed many years ago. Currently we can see that IOT devices, smart watches and mobile phone manufacturers as Samsung and Apple start to implement the eSIM

technology to their products. But there are also other device and gadget manufacturers that start using over the air SIM provisioning technologies. In this article, we will talk about the meaningful problems when offloading information traffic on a Wi-Fi network. Also, we will investigate eSIM technology, it's processes and its use in practical aspects. How this virtual SIM card technology is used nowadays and in which variations and implementations we can meet it.

Materials and methods

The research involves the methods of logical and comparative analysis. For the comparative analysis of virtual SIM technology these technologies were investigated.

Built-in eSIM technology offers an elegant, reliable and virtually infinitely scalable solution for legacy SIM card calls in IoT applications. ESIM is still a physical SIM, but instead of being removable, it is constantly soldered to the device. Authorized users can access profiles and other data in eSIM and update them using a wireless SIM card provisioning (RSP) solution[5]. The problem of SIM cards exists not only for smartphones, but also for smart things. Therefore, ARM has developed iSIM for all IoT devices. New technology allows you to embed a SIM card in processors to save even more space. The developed ARM card occupies "a fraction of one square millimeter." For comparison, eSIM, although smaller than nano-SIM, still occupies 6 x 5 mm of space in the phone. The technology is intended primarily for small IoT devices - for example, for wireless sensors that need to transmit data using mobile communications. ARM's goal is to minimize the cost of these products. In the future, technology can be used in other devices, including smartphones. eSIM and iSIM solves the problems that current physical SIM card solution has:

- Small in size. 5 × 6 millimeters ESIM is about half the size of a Nano SIM card, which is 12 × 8.8 millimeters. iSIM measures in nanometers, part of a Nano SIM card. This further reduction in size gives device manufacturers greater design flexibility and reduces their manufacturing costs.
- Can be controlled remotely. You can remotely manage profiles to change networks or update settings on virtually any number of eSIM devices using RSP technology.
- Proof of hacking. You cannot quit and accidentally step on eSIM.
- Proof of theft. You cannot steal eSIM.

It can be argued that eSIM was a revolutionary innovation, as it significantly reduced the cost and complexity of managing physical SIM cards, which makes IoT scalable. As a result, companies that deploy a large number of IoT devices are not tied to their original network operator or its pricing and access policies. iSIM strengthens and expands these and other qualities, and also eliminates some of the disadvantages of eSIM. The main innovation of iSIM is that it transfers the functionality of the SIM card to the device's permanent hardware array. However, unlike eSIM, iSIM no longer uses a separate processor; nor does it require a significant fraction of the hardware footprint of the device[6]. Instead, iSIM allows equipment manufacturers and processor companies to design system-on-a-chip (SOC) architectures that combine the functionality of a SIM card with an existing embedded processor and cellular modem[7]. There are also another implementations such as softSIM and cloudSIM. SoftSIM are a conceptual capability in a device. It can be provisioned remotely over the air. There is no SIM at all in the divice. The provisioning information is held in memory as a part of other computing equipment. Most of phone companies are against these because they are perceived as more exposed of question of hacking. But currenltly we can see softSIM solution from KnowRoaming company that is implemented in ZTE and Alcatel phones. Building on SIM Security Benefits eSIM offers another major enhancement that benefits every mobile device: security. Physical SIM cards have always been more secure than software standards, since hardware systems are inherently more difficult to crack. eSIM and iSIM are difficult to steal, which increases the reliability and integrity of the devices that use them. iSIM then relies on eSIM and SIM security credentials. Located in a secure enclave in a system-on-a-chip (SoC) system, it provides the root of confidence for the mobile network, made possible by an additional level of authentication. This reuse is especially useful in payment, identification, and critical infrastructure

applications. The advantage of iSIM it all comes down to cost because iSIM devices require fewer components, assembling them is cheaper. And, as a rule, the simpler design of iSIM also leads to the creation of more reliable and, therefore, less expensive devices. Per unit cost advantage of iSIM can be small. But when an organization purchases hundreds of thousands of IoT devices at the same time, such a small cost reduction can result in significant savings. The cost advantage of iSIM is becoming more important given the growing market for IoT devices, which must be very small, reliable, and inexpensive to use.

Results

Offloading mobile data is expected to become a key industry segment in the near future due to the unprecedented growth rate of data traffic on mobile networks. Wi-Fi offloading has evolved into a mature offloading solution. Most carriers around the world have begun deploying Wi-Fi offload solutions. However, there are a number of problems that must be correctly addressed in order to create a successful unloading mechanism. Key issues include spatial and temporal estimates for unloading, planning and deployment issues, choice of backhaul, device limitations, and charging mechanisms. Such problems can be properly addressed by the joint efforts of all participants in the value chain of mobile data transmission. We can see that there are a high variety of virtual SIM technologies used in different implementations, which are somehow differ in implementation of provisioning and storing SIM profile. During the analysis of virtual SIM technologies it was find out that the most popular and secure for nowadays is eSIM technology for provisioning SIM profiles OTA that was set a new standard related to embedded Subscribed Identity Module. But we should keep in mind the cost advantage of iSIM is becoming more important given the growing market for IoT devices, which must be very small, reliable, and inexpensive to use. Future work enclosed in the developing of personal router that works on eSIM technology and developing personal algorithm for Wi-Fi offloading to seamless switching between cellular data and Wi-Fi.

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