A 3W Network Strategy for Mobile Data Traffic Offloading

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ABSTRACT

This article presents a quantitative survey of mobile data traffic surge and a strategic solution to traffic offloading. As diverse mobile devices such as smartphones and tablet computers become ubiquitous, the explosive increase of data traffic in 3G cellular networks is a major concern for network operators. The rapid increase of mobile data traffic is unprecedented — a tenfold increase in a year is common. Thus, mobile data traffic offloading in 3G cellular networks is necessary. In this article we examine the effect of a network strategy deploying multiple wireless networks. We first discuss the relationship between the spread of smartphones and their contribution to the mobile data traffic surge. To see how mobile data traffic is transferred among different networks, we illustrate the traffic trend of the 3W (WCDMA, WIBRO, and WiFi) network in KT Corporation. Based on the composition of traffic, we also discuss functions and roles of the 3W networks in accessing mobile Internet. From these results, we show that deploying multiple wireless networks is an effective way of traffic offloading.

INTRODUCTION

Mobile data traffic represents an increasingly large share of Internet traffic. AT&T acknowledged a 5000 percent growth in wireless data traffic in three years (2006–2009), since the iPhone launch [1]. The growth of cellular data traffic has been forecasted to outstrip fixed-line Internet traffic by a factor of 10 in 2009–2014 [2]. Most of this traffic is generated by smartphones, with easy and quasi-ubiquitous access to streaming media for video and audio, sales of which are projected to surpass desktop PC sales by the end of 2011 [3].

Unfortunately, this explosive surge in mobile data traffic has caused unprecedented pressure on the limited spectrum of the current third-generation (3G) cellular networks, pushing them to capacity limits in many geographical areas. Moreover, signaling traffic causes a significant burden on the 3G core networks as the multitudinous smartphone applications proliferate. Many smartphone applications such as mobile messengers and social networking applications frequently communicate with application servers or peers in order to keep their connections alive. In conjunction with always-on characteristics, smartphones cause a lot of signaling traffic in the 3G networks.

The cost of supporting the exponentially increasing mobile data traffic is becoming unsustainable: the rising cost of service delivery is outrunning the increased revenues. Subscribers, particularly in metropolitan areas, are experiencing deteriorating 3G quality during peak times because the network is congested with the high demand [4]. In response to the increase of data traffic, both the industry and research communities have been moving quickly to address the rapid traffic growth with a low-cost viable solution, 3G data traffic offloading [5–8]; reducing the pressure on 3G spectrum by using complementary network technologies to deliver data originally targeted for cellular networks.

This article briefly reviews various mobile data offloading solutions and then presents a snapshot of the real-world case of 3G data offloading supported by KT Corporation, whose wireless market share is 31.6 percent with 16 million subscribers in Korea [9]. KT has recently implemented and deployed the 3W — wideband code-division multiple access (WCDMA), WiMAX (called wireless broadband [WIBRO] in Korea), and WiFi — network strategy for efficient handling and offloading of mobile data traffic, which is discussed in detail later.

We highlight the main contributions from this article:
• We briefly review various mobile data offloading solutions, including direct tunneling, gateway offloading, traffic policing/shaping-based offloading, and WiFi or femtocell offloading.
• We present a high-level summary of the usage statistics, traffic composition, and growth trends of KT's 3W wireless networks, WCDMA,

WiFi, and WiBro, in 2010, in terms of the number of subscribers and the amount of total traffic. Due to the proliferation of smartphones (in particular, the Apple iPhone) and introduction of flat-rate pricing, we have observed a tenfold data traffic surge in our WCDMA network in 12 months, from around 0.9 to 9.1 Gb/s on average. The total amount of mobile traffic served by all three networks has increased from around 3 Pbytes/month to 5.2 Pbytes/month in the same period.

• We also present how much traffic an average user has generated in each of the three different mobile networks. In 2010, the average monthly traffic per subscriber in our WCDMA, WiFi, and WiBRO increased from 100 to 450 Mbytes, from 80 to 160 Mbytes, and from 7 to 11 Gbytes, respectively. The results clearly indicate that strategically deploying multiple different types of wireless networks addressing different needs/scenarios of mobile users is an effective way to handle the huge amount of 3G mobile data traffic.

The rest of this article is organized as follows. We describe the deployment of 3W networks in KT Corporation. We briefly review existing mobile data offloading solutions and discuss how mobile data traffic offloading is attained among the 3W networks. We show how the 3W networks of KT were used in 2010, in terms of the number of subscribers and the amount of total traffic, as well as per-user generated traffic. We then conclude the article.

DEPLOYMENT OF 3W NETWORKS

This section describes the evolution and deployment of 3W wireless networks in KT Corporation. KT Corporation launched its 3G cellular service in 2007. Although it operated a nationwide 2G CDMA network, a new service based on 3G WCDMA was launched first in Korea to provide high-speed data and multimedia services and global roaming. Since the 2G cellular mobile telecommunications service started in 1996, the life of facilites was close to its end. Moreover, the frequency band of 2G service was 1.8 GHz, which was used only in Korea. Hence it was preferred to deploy a new mobile communications network rather than to upgrade its 2G cellular network to Evolution-Data Only (EV-DO).

The 3G WCDMA service started in conformance with Third Generation Partnership Program (3GPP) Release 4, and was upgraded based on Releases 5 and 6 to furnish high-speed downlink/uplink packet access (HSDPA/HSUPA) functionalities. The number of subscribers for the 2G and 3G cellular services together exceeded 16 million in December 2010, and the mobile telecommunications market share was 31.6 percent in Korea [9].

WIBRO service provides portable mobile broadband connectivity across cities and countries through a variety of devices. WIBRO is the Korean name for the IEEE 802.16e (mobile WiMAX) international standard. The first commercial WIBRO service started in the Seoul metropolitan area in June 2006. Service coverage was expanded to 19 neighboring cities near

Type	Coverage	Offered service
WCDMA	Nationwide	Voice and low-volume data
WIBRO	84 cities	High-speed data
WiFi	Indoor hotspot	High-speed data

Table 1. *Coverage and offered service type of 3W networks.*

Seoul and five metropolitan areas in 2008 and 2010, respectively. The coverage was expanded to 59 local cities in 2011; thus, the service is now provided in 84 cities in Korea. The pricing policy of WIBRO is usage-based, and subscribers can use up to 50 Gbytes a month for $25.

Most subscribers use the WIBRO service with laptop or netbook computers that are equipped with internal modems or external USB dongles. Other types of terminals are also available such as smartphones, portable media players, or navigation devices. While the number of WIBRO subscribers does not change a lot, the introduction of a wireless LAN access point (AP) using the WIBRO as a backhaul network contributed to wide service dissemination and increase of traffic. WIBRO routers, called egg terminals, are being installed in public transportation such as subway or railway trains and buses. Personal WIBRO routers providing WiFi connectivity while in motion are also available.

WiFi service was first introduced in the early 2000s with the growth of broadband Internet service. KT provided public hotspot zones and home APs to its broadband subscribers for an additional charge ($10 for unlimited data). The number of WiFi subscribers did not achieve economy of scale because the service coverage was limited. The total number of hotspot zones was 13,000 by 2010.

However, WiFi hotspot zones turn out to be an important network infrastructure as smart devices equipped with WiFi connectivity are widespread. Although WiFi provides small coverage areas and has limited mobility, it can offload data traffic from 3G cellular networks, as exemplified in the case of AT&T [8]. KT started to build WiFi hotspot or street zones in 2010, and the number of hotspot zones exceeds 40,000. It plans to expand the number of public hotspot zones to 100,000 in 2011. The WiFi hotspot zones are available for free to smartphone subscribers of KT.

We summarize the strategic positioning of 3W networks based on coverage and available terminal equipment. The 3G cellular network offers nationwide coverage for the most diverse devices such as smartphones, feature phones, tablets, and even notebook computers through tethering. The WIBRO network covers only urban areas (84 major cities) and provides high-speed data service up to 30 Mb/s. Users can access the WIBRO network with internal or external modems and WiFi-enabled devices such as egg terminals. WiFi covers indoor hotspots and street zones, and provides the highest bandwidth of the three networks.
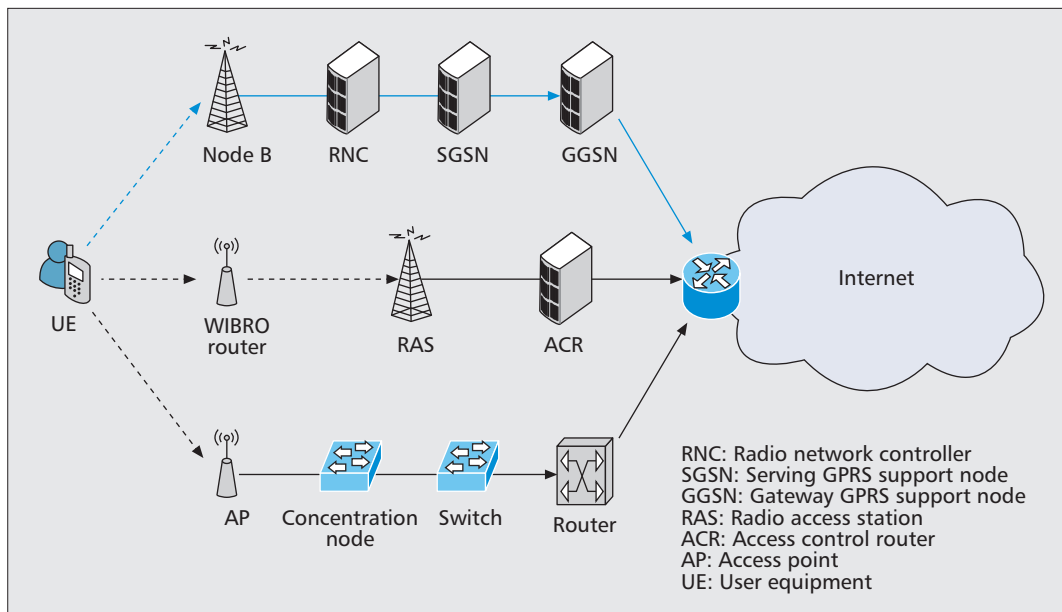
Figure 1. *Overview of 3W network architecture. Smartphone users can access the Internet with WCDMA packet service or WiFi. The WiFi network has two backhaul networks in KT Corportation, i.e. traditional wired network and WIBRO.*

TRAFFIC OFFLOADING IN 3W NETWORKS

To handle the increasing mobile data traffic more efficiently, current 3G networks continue to be enhanced and optimized. Before we discuss the traffic offloading in 3W networks, we briefly review offloading solutions. Several solutions are available in the market: serving general packet radio service (GPRS) support node (SGSN) direct tunneling, offloading gateway, traffic policing/shaping-based, and WiFi/femtocell offloading.

Direct tunneling enables the SGSN to establish a direct user plane tunnel between a radio network controller (RNC) and a gateway GPRS support node (GGSN). Through the tunnel, user data traffic can bypass the SGSN to reduce the loads. However, signaling traffic loads in the control plane are still handled with the SGSN. A more recent advancement over direct tunneling is SGSN and GGSN *gateway offloading*, where an offloading gateway is inserted between the RNC and SGSN. The gateway monitors radio access network application part (RANAP) control traffic and detects if a session is requested for an Internet bound session or an operator-provided service (i.e., walled garden). If the session is for a walled garden service, the gateway does nothing. Otherwise, if the session is bound for the Internet and the service provider sees no incremental opportunity to add value, the gateway lets traffic bypass the SGSN and GGSN, relieving not only the SGSN but also the GGSN from traffic loads, and forwards the traffic to the nearest Internet peering point.

Traffic policing/shaping-based offloading solutions typically exploit deep packet inspection (DPI) technology, with which operators can inspect packet payloads (i.e., application-level user data) to identify certain classes of traffic and then perform various preplanned operations on the traffic (e.g., compress and/or cache the contents).

WiFi or *femtocell offloading* reduces the pressure on 3G spectrum by using alternative networks like WiFi or femtocells (small micro sites of cellular coverage) when possible for transferring data [5–7]. WiFi has naturally emerged as a low-cost viable solution for operators to handle the data traffic surge in 3G networks, due to the built-in WiFi capabilities of smartphones on the market. Most smartphones with WiFi capability are currently configured by default to give higher priority to WiFi over the cellular interface for data transmissions [6]. In addition to reducing pressure on 3G spectrum, it has also been reported that WiFi offloading can lower the cost of data transfers by 70 percent [8].

Next, we discuss how traffic offloading is attained among 3W networks. An overview of 3W network configuration is shown in Fig. 1. Smartphone subscribers of KT can use WCDMA packet service (PS) or WiFi networks to access mobile data sevice. As explained in the previous section, users access the Internet with WiFi through two backhaul networks: the conventional wired network and WIBRO.

Mobile data traffic offloading depends on users' discretion turning on WiFi capability in their mobile devices. There are applications that compel users to make use of WiFi. Some applications restrict downloading data larger than 20–30 Mbytes or watching streaming videos to WiFi only, and thereby traffic offloading is encouraged. While WiFi offers more bandwidth than WCDMA, it is not always preferred to use WiFi for reasons such as the inconvenience of turning WiFi on/off, limited coverage and mobility, and, more important, flat-rate pricing for unlimited WCDMA data usage. However, the WiFi traffic generated from smartphones is increasing as more WiFi hotspot or street zones are built. As we see in the next section, the total

amount of WIBRO traffic is also increasing, while the number of subscribers has not changed a lot. We believe it is an indication of widespread use of the WIBRO network including egg terminals. To fully utilize the traffic offloading with WiFi, KT plans to introduce an access network discovery and selection function (ANDSF) in order to inform users of WiFi availability.

Although WiFi networks are available free to smartphone subscribers of KT Corporation, authentication and authorization is required to access WiFi. The authentication method varies depending on the types of devices. Smartphones are verified with medium access control (MAC) or universal subscriber identity module (USIM) authentication, while laptops and netbook computers use ID/password or MAC authentication. Using the authentication information, we discriminate traffic used in this article based on terminal types.

STATUS OF MOBILE DATA TRAFFIC

In this section, we investigate the traffic variations in 3W networks and the offloading effect of WiFi. First, we discuss the trend of smartphone proliferation and how it contributes to the surge of data trafic in the WCDMA network. We next observe the mobile traffic composition among 3W networks and show evidence to substantiate the traffic offloading effect of WiFi.

SMARTPHONE PROLIFERATION AND DATA TRAFFIC SURGE

Figure 2 shows the trend of smartphone proliferation in KT Corporation. Before the iPhone release in November 2009, only a small number of subscribers had been using smartphones such as Windows Mobile or Blackberry phones. The introduction of the iPhone changed the mobile communications market and set off the massive transition from feature phones to smartphones. By December 2010, the number of smartphone users exceeded 6 million, which was approximately 12 percent of mobile communications service subscribers in Korea [9]. By December 2010 the number of smartphone users subscribed to KT was 2.7 million, accounting for approximately 19 percent of total subscribers, which was much higher than the average (12 percent) in Korea [10].

Smartphone users generate more data traffic than feature phone users. While feature phone users make use of data services provided by mobile network operators such as short, long, or multimedia message service and walled garden portal service, smartphone users utilize a broad range of data services such as email, web browsing, social networking, and video streaming. Consequently, smartphones contribute to the data traffic surge in the WCDMA network.

In the case of our WCDMA network, the data traffic increase was tenfold in 2010 when the traffic is measured at an interface connecting GGSNs to the Internet backbone. The monthly average traffic at peak times increased from 0.9 Gb/s in December 2009 to 9.1 Gb/s in December 2010. It is clear that the increase of mobile Internet traffic is proportional to the number of
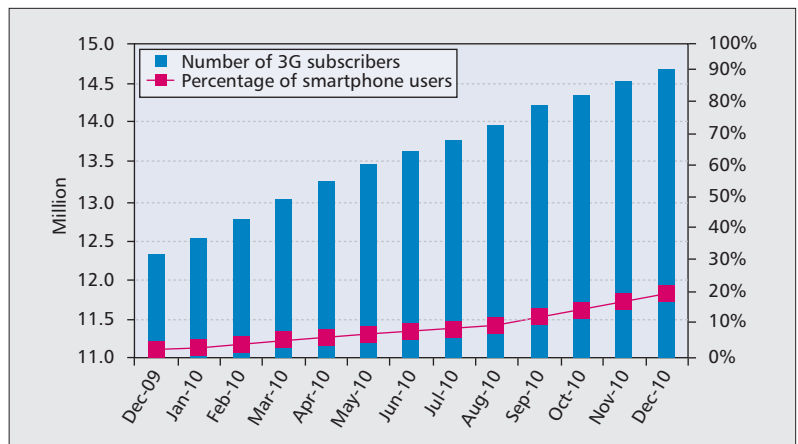

Figure 2. *Trend of the number of WCDMA subscribers and percentage of smartphone users.*
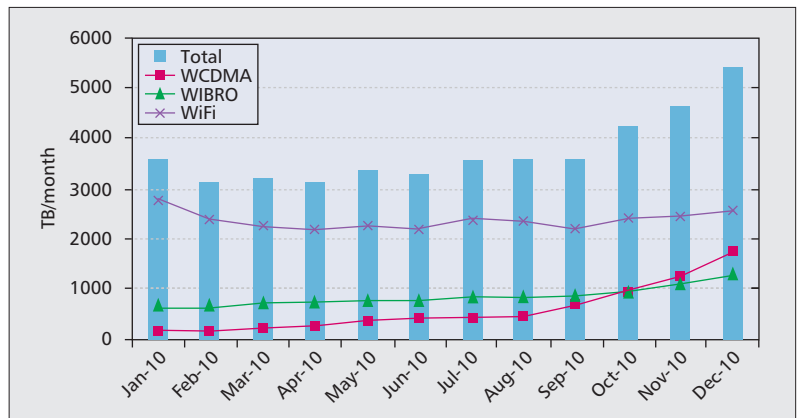

Figure 3. *Monthly mobile Internet traffic volume of the 3W networks. In case of WIBRO and WiFi, the data is given by the total traffic generated from other devices besides smartphones. In addition, the WiFi traffic is collected according to the APs supplied by KT Corporation (hotspot zones and home APs). Thus, the WIBRO and WiFi data mostly consist of traffic from traditional mobile devices such as notebooks.*

smartphone users. However, the dramatic increase in mobile data traffic is heavily influenced by the pricing policy. The increasing rate of data traffic became steep when flat-rate pricing for unlimited data usage was introduced in September 2010. Thus, the arrival of smartphones combined with flat-rate pricing led to the tenfold data traffic surge in a year.

TRAFFIC COMPOSITION IN THE 3W NETWORKS

Mobile traffic composition among the 3W networks is shown in Fig. 3. In this figure, the total mobile traffic increases during 2010 as diverse mobile devices become widespread. The net increase in mobile data traffic is attributed to WCDMA and WIBRO traffic, while WiFi traffic does not vary that much. The proportion of WiFi traffic is reduced to approximately 50 percent of the total mobile network traffic in December 2010, while it was more than 70 percent in December 2009. On the other hand, the proportion of WCDMA traffic has increased to 30 percent of total mobile network traffic, while it was less than 5 percent a year ago. This figure shows that the WCDMA network plays an
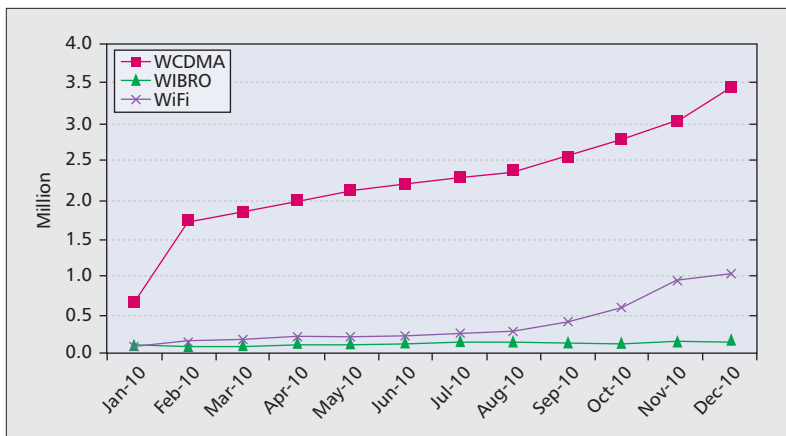
Figure 4. *Number of subscribers accessing mobile Internet through the 3W networks. The number of WCDMA and WiFi subscribers corresponds to the smartphone users accessing WCDMA and WiFi networks, respectively. The smartphones users accessing WiFi is computed with the AAA (Authentication, Authorization and Accounting) servers which have the information on types of devices. However, the number of WIBRO subscribers is not related with the number of smartphone users accessing WIBRO.*
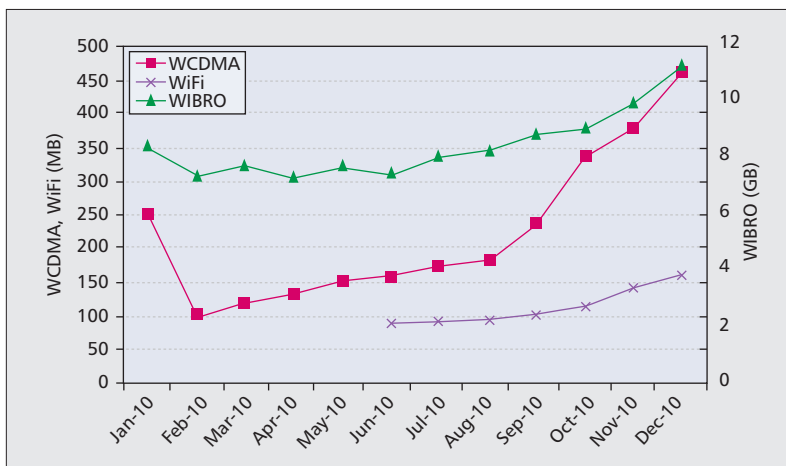

Figure 5. *Monthly traffic volume per user for the 3W networks. The WiFi traffic volume from smartphone users is available since June 2010. In the case of WCDMA, the monthly traffic volume per user in January 2010 is not conforming with the trend of increase. It can be explained by the characteristics of users in January 2010, since early adopters might have purchased smartphones and used them heavily.*

increasingly important role in 3W networks when smart devices are pervasive and flat-rate pricing is available.

Figure 4 shows the monthly average number of subscribers accessing each of the 3W networks. In this figure we observe that users accessing the mobile Internet make use of WCDMA mostly. The widespread use of WCDMA in accessing mobile Internet can be inferred from coverage of the WCDMA network and diverse devices such as smartphones, feature phones, tablets, and even notebook computers with tethering. The number of subscribers accessing WiFi is also increasing since August 2010 as WiFi hotspots are massively deployed. While the number of WIBRO users stays smaller than the other two networks, it has increased by 40 percent in 2010, which also indicates widespread usage of mobile Internet in Korea.

Next, we examine monthly traffic volume per subscriber of the 3W networks. While most mobile Internet users access the WCDMA network, the monthly traffic volume per user is small compared to that of WIBRO. However, monthly data traffic volume per WCDMA user rapidly increased after the introduction of flat-rate pricing in September 2010. Monthly traffic volume per WiFi user is small compared to that of WCDMA but also increased in late 2010. Monthly traffic volume per WIBRO user shows the characteristics of the subscribers of the service. The WIBRO subscribers represent a heavy group of mobile Internet service users, and the traffic volume per user has recently exceeded 10 Gbytes/mo.

Conclusively we categorize the positioning of the 3W networks as follows:
• WCDMA offers nationwide coverage for voice and low-volume data service.
• WIFI covers indoor hotspots or street zones for high-speed data service.
• WIBRO covers 84 urban cities for high-speed data service of heavy users.

As exemplified in this article, deploying multiple wireless networks including WIBRO and WiFi can help deal with the mobile data traffic surge in 3G cellular networks caused by smartphones and flat-rate or low-cost services.

CONCLUDING REMARKS

This article presents a quantitative study of mobile data traffic surge and a strategic solution implemented for traffic offloading by KT Corporation. As smartphones including the Apple iPhone have become pervasive in Korea, we observed a tenfold mobile data traffic surge in our WCDMA network in 2010. Traffic offloading of the WCDMA network is necessary; thus, several solutions have already been proposed, such as SGSN direct tunneling, gateway offloading, and traffic policing/shaping based on deep packet inspection. In this article we survey how deploying multiple mobile networks can be effective in sharing the traffic load of the WCDMA network. We discuss the usage trend and growth of 3W (WCDMA, WIBRO, and WiFi) network traffic in KT Corporation, and how users access each network. We also investigate the composition of mobile data traffic generated by smartphones. We believe that traffic offloading is expected to be increasingly indispensable in the near future, and multiple network deployments including WiFi and LTE will be effective.

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