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Data Collection via Synthetic Aperture Radiometry towards Global System

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ABSTRACT
Nowadays it is widely accepted that remote sensing is an efficient way of large data management philosophy. In this paper, we present a future view of the big data collection by synthetic aperture radiometry as a passive microwave remote sensing towards building a global monitoring system. Since the collected data may not have any value, it is mandatory to analyses these data in order to get valuable and beneficial information with respect to their base data. The collected data by synthetic aperture radiometry is one of the high resolution earth observation, these data will be an intensive problems, Meanwhile, Synthetic Aperture Radar able to work in several bands, X, C, S, L and P-band. The important role of synthetic aperture radiometry is how to collect data from areas with inadequate network infrastructures where the ground network facilities were destroyed. The future concern is to establish a new global data management system, which is supported by the groups of international teams working to develop technology based on international regulations. There is no doubt that the existing techniques are so limited to solve big data problems totally. There is a lot of work towards improving 2-D and 3-D SAR to get better resolution.

***Keywords* –** Global system, Synthetic Aperture radiometry, L-Band, Passive remote sensing.

I. INTRODUCTION

Nowadays Engineers are looking for the role of satellite technology to provide pivotal communication links to out of reach areas. Installing terrestrial networks in different areas of the world can be costly, although there are a lot of regions that are not logged on yet, they rely heavily on satellite connectivity. For example, impossible to connect users at sea or in the air can only connect by using the satellite. Also in this case, there is no profitable way to justify the costs to rollout fiber to remote link, sparsely populated areas because the frequency range that the satellite communications has is limited, and regulated by international agreements. The IoT is expected to continue driving up demand for the integration of satellite and high altitude Internet services. [1] The future IoT will be a cognitive IoT with large numbers of various interconnected devices, these generate a massive data in an explosively. The data we collect may not have any value, so data analysis, interpret, understand is mandatory now to get a valuable and beneficial information with respect to their base data. [2] This future concern towards a global system is how to use a new satellite communication to collect a data from some areas which are not included any sensor. That might be a significant challenge towards a smart society. The important thing is how to collect the data from a huge number of things or from a huge area with low cost and short range such as rural areas or desert or sea to predict any disaster. Satellite collects data from sensor or the reflected signal from passive microwave radiometer and sends the data to ground stations or any other cloud station to materialize such smart systems, it is needed to collect data from these smart things with sensor or material depend on their reflection as a microwave radiometry using synthetic aperture or any other L-band techniques. Microwave radiometer is an important tool for passive remote sensing of the earth. Traditionally, it images the brightness temperature distribution by scanning a real aperture antenna beam across the desired field. The resolution is determined by the ratio of wavelength and aperture size. To accomplish a high resolution for a given frequency and distance to the object, one has to enlarge the aperture size of the antenna. The Synthetic aperture radiometer (SAR) is the most promising technique for passive remote sensing. It has the ability to achieve high resolution without suffering of the problem of deploying large scanning antenna that exists in the traditional real aperture radiometer. There are many airborne SAR systems have been developed [3], such as ESTAR are the representative ones. On the other hand, there is the space borne application projects of the SAR system like ESA's SMOS/MIRAS [4] are also being implemented. These applications of the aircraft or spacecraft instruments are all operated in the far field of the antenna array. Because of the development and maturity of integrating digital correlator technology, this led to the increasing in the interest of applying SAR in short range imaging applications like, security, detection of concealed weapons or other contrabands, all weather reconnaissance and surveillance, and ground penetrating imaging for landmine detection or archeology[5].

II. SYNTHETIC APERTURE RADIOMETRY

Synthetic Aperture synthesis (SAR) is an interferometry technology for passive microwave remote sensing it is solving the problem of putting large apertures in space since it is working as imaging radar, that high-resolution radar images of the earth's surface can be produced from airborne and spaceborne platforms. This technology has the ability of imaging in the day-and-night, because SAR is working as an active sensor, also the microwave band uses the in the broad radio spectrum, in addition it is able to penetrate could cover, and to some extent, rain. The principal of SAR working technique is similar to a large extent to earth-rotation synthesis employed in radio astronomy. It can be described as a product of pairs of small antennas while the signal processing is used in place of a single large aperture. The coherent product in the aperture synthesis of the signal is measured the different antenna-pair spacing (baselines). So the result of that product at each baseline give a sample point in the Fourier transform of the brightness temperature map of the scene, and by inverting the sampled transform, the scene itself is reconstructed [6][7].

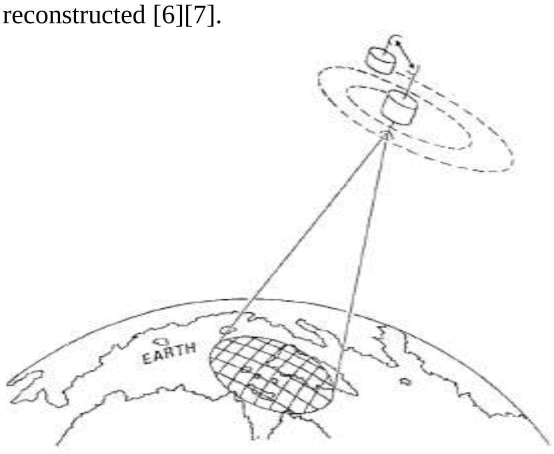

Figure (1) Space synthesis for remote sensing

Figure (1) shows how this technique works to remote sensing from space. Imagine two antennas in orbit, one spiraling around the other, and each looking at the same regime on the surface (indicated by the oval).

At intervals indicated by the dashes, the signals which are taken from the two antennas are multiplied and averaged. It is readily shown that this product is proportional to the Fourier transform of the brightness temperature of the scene evaluated at a frequency that depends on the spacing between antennas. The predecessor of the present two-dimensional synthetic-aperture radiometer is a one-dimensional one, named the Electrically Scanned Thinned Array Radiometer (ESTAR) [3]. The ESTAR is operating in the L – band and it employs an aperture synthesis in the cross-track dimension only, while using a conventional antenna for resolution in the along-track dimension. On the other hand the two-dimensional instrument also operates in the L - band to be precise, at a frequency of 1.413 GHz in the frequency band restricted for passive use (no transmission) only such as the SMOS (Soil Moisture and Ocean Salinity) which is based on the MIRAS (Microwave Imaging Radiometer with Aperture Synthesis). The following sections explain in more details the ESTAR and the SMOS. [4], [8].

III. ESTAR

ESTAR is an instrument prototype developed by the Goddard Space Flight Center and the University of Massachusetts, Amherst, to develop the technology of aperture synthesis for remote sensing. It represents a technology which was developed for passive microwave remote sensing of the environment from space. It has been demonstrated successfully using an aircraft instrument called ESTAR. It is an L -band radiometer in the hybrid configuration designed for remote sensing of soil moisture where the need for large apertures in space is greatest. The hybrid configuration was adopted because it is practical for application in space and involves relatively simple processing [3].

The real antennas in ESTAR are linear arrays which are horizontally polarized dipoles with their long axis in the direction of motion as shown in figure (2). The stick antennas produce a narrow "fan" beam that provided with good resolution along the track and essentially, on the other hand there is no resolution in the across track dimension. Resolution across the track is obtained using aperture synthesis. This is the configuration used in the aircraft prototype. [8], [9]

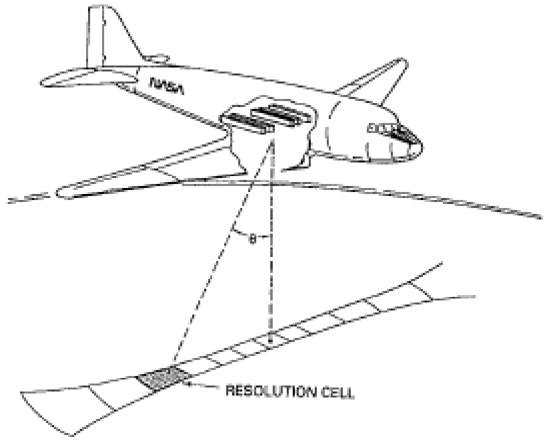

Figure (2) ESTAR radiometer configuration

IV. SMOS

The Soil Moisture and Ocean Salinity (SMOS) mission is an Earth Explorer Opportunity mission of the European Space Agency (ESA). It is the first 2-D aperture synthesis radiometer for Earth observation. The mission of the SMOS is to produce global maps of soil moisture and ocean salinity using the Microwave Imaging Radiometer by Aperture Synthesis (MIRAS) [4].

In addition to the data which assist in an in-depth study of the structure of the Cryosphere. Because to date, it doesn't have the ability to obtain moisture and tracking maps from space, since the measurement of these geophysical parameters is localized and not continuous. For this reason it is a good idea to have a satellite for providing the measurement of the planet's two geophysical parameters over the entire surface and with a high rate of repetition. The SMOS is designed to operate at L –band and employs an aperture synthesis in two dimensions, in addition to that, it employs antennas in the "Y" configuration as shown in Figure 3. [3].

In the SMOS configuration the "Y" is tilted forward at an angle of about 21 with respect to nadir. On the other hand the arms are about 4.5-m long and contain 27 antennas spaced 0.8 wavelengths apart. The analyses show that this configuration, with antennas distributed along the arms has the ability of optimizing space resolution and Instrument sensitivity. There are three segments of which are connected by a hinge. The arms are folded to the sides of the central structure during launch. [9].

Figure (3) SMOS radiometer configuration

V. SAR APPLICATION

The SAR is used in different area of research such as oceanography to archeology the following are some selected fields of SAR application examples. Note that not all applications are in practical use; many applications are still in developing stages [6].

- Hydrology: it is used in the following branch such as, wetland, river flow, soil moisture ,water equivalent snow & ice, drainage pattern, water cycle, water resources in the desert
- Agriculture: for Agriculture it is important in the following area like, plantation acreage or crop classification, soil moisture, growth, harvest and the disaster.
- Cryosphere: it can be considered a good idea for the distribution & changes of ice & snow on land also, classification or iceberg tracking, equivalent water, sea & lake, ice age, glacier flow, ship navigation in sea ice
- Urban :the urban represent the structure & density, subsidence, traffic monitoring ,urbanization, skyscraper height estimation and the change detection
- Forestry: for the forestry it used in forest fire monitoring, tree biomass, species, height, plantation and deforestation.
- Geology: topography, DEM & DSM production, crust movement, faults, GIS, soil structure, lithology, underground resources
- Disaster: prediction, lifeline search, monitoring of damage & recovery, tsunami & high tide landslide & subsidence by earthquake, volcano & groundwater extraction.
- Archeology: exploration of aboveground and underground remains, survey, management
- Oceanography: ocean waves, internal waves, wind, ship detection, identification & navigation, currents, front, circulation, oil slick, offshore oil field, bottom topography [10].

VI. FUTURE VISION OF SAR

There is a lot of work towards improving SAR in different branches, but the general trends are that the spatial resolution is becoming better, wide-swath scan modes with coarser resolution and different beam modes are available including high-resolution spotlight as shown in figure (4). The conventional single-polarization mode is becoming dual or full Polari metric modes.

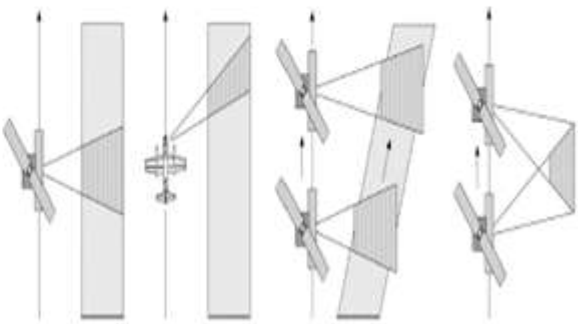

Figure (4) Different beams modes, left to right: strip (map), squint strip (map), wide-swath scan, and spotlight modes.

There are many airborne SARs which are

developed by various organizations and all resent systems are operating at multi-frequency full polarization mode, on the other had, some of which are equipped with cross-track and/or along-track interferometric modes. The spatial resolution is order of meters or less [6].

In addition to the improving resolution and altitude, the main difference of airborne SARs is the motion compensation requirement. Since the platform of spaceborne SARs is relatively stable, in contrast the airborne SARs usually are suffering from platform instability which is caused by the variety of the speed and/or motion of aircrafts. Since the azimuth reference signal assumes a stable platform path, the azimuth reference signal does not "match" the signal in raw data, and the images are degraded. For this reason it is necessary to estimate the platform movement to produce a correct azimuth reference signal so the images can be formed of high quality by airborne SARs [11].

In addition, it should be mentioned that space borne SARs, in particular interferometric SARs, sometimes suffer from image degradation by tropospheric and ionospheric effects. High-frequency airborne SARs may have some effects when imaging through dense rain cells, but in general, they are not affected by the atmospheric effects [6].

VII. L-BAND

Microwave radiometers play an important role in Earth observation as a remote sensing. Numerous environmental parameters are efficiently monitored by passive microwave techniques. For regular Earth observation purposes the radar covers an angle range of 25 to 60 degrees at altitudes of up to 6km above sea level. The frequency range that the satellite communications has is limited, and regulated by international agreements. The spectrum must be used in the best and most efficient manner.

Figure (5) L-band airborne location

Passive microwave remote sensing from space at L band has the penetrating advantages of atmosphere. The satellite M2M and IoT connections will rise up to 5.8 million globally. This is done by using L-band with over 93% of in-service terminals in 2023. [xxx] Synthetic Aperture Radar able to work in full Polarimetric in four bands, X, C, S, L and P-band, which cover the wavelengths from 3 to 85 cm. In Here, only the L-band is used. The modes of measurement contain single channel operation (1 wavelength and polarization at a time), table shown below. [12]

Band	Frequency Range	Total Bandwidth	General Application
L	1 to 2 GHz	1 GHz	Mobile satellite service (MSS)
S	2 to 4 GHz	2 GHz	MSS, NASA, deep space research
C	4 to 8 GHz	4 GHz	Fixed satellite service (FSS)
X	8 to 12.5 GHz	4.5 GHz	FSS military, terrestrial earth exploration, meteorological satellites
Ku	12.5 to 18 GHz	5.5 GHz	FSS, broadcast satellite service (BSS)
K	18 to 26.5 GHz	8.5 GHz	BSS, FSS
Ka	26.5 to 40 GHz	13.5 GHz	FSS

Table (1) Satellite bands [1]

As a case study; Japan aerospace agency developed an aerospace called ALOS earth observation Radar-Sat based on L-band, this type of L-band Synthetic Aperture Radar is an active microwave sensor using L-band frequency to achieve cloud free, day and night earth observation.

This project will enable to obtain 250 to 350km width of SAR images of spatial resolution. This swath is 3-5 times wider than conventional SAR, The project includes a special type of sensors which have a beam steerable in elevation and operate at L-band.

VIII. WHY GLOBAL TREND

The future mission is to establish a new global data management system, which is supported by the groups of international teams working to develop technology based on international regulations. The resulting system of cooperation provides an international mechanism to broaden the exact and hidden value of these data into vital information for society as shown in below diagram. The important role of the space information technology is to achieve development in earth observation, instead to build a huge number of sensors in some specific area to manage natural resources. Constellations of small and medium satellites are emerging as promising tools to assess, monitor, and to share data on expected natural disasters. Because of the amount of data satellites produced in a month is so huge, so the question comes is how the data are going to be managed specially many of these satellite and airborne systems are built individually by governments or some organizations for their own purposes. Now is widely accepted that remote sensing is an efficient way of large data management philosophy. Over the world are tens of satellites with sensors lies to make a numerous kind of accurate, and high resolution remotely sensed data, to measure changes in any area of interest, on earth, there are tens of thousands stations have been installed, using special sensors aboard aircraft to measure the atmosphere and the land, this massive amount of data has the potential to help us in many ways, from disaster prediction to another phenomenon's management.

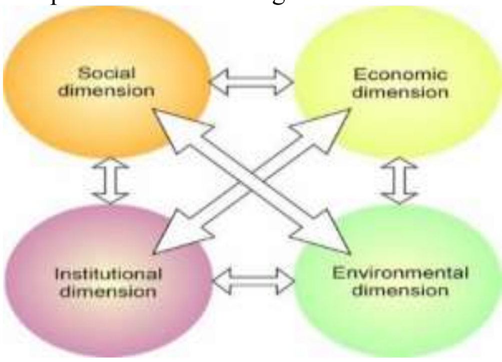

Figure (6) global system.

To take the advantage of the satellite and airborne by using L-band and Synthetic aperture radiometry is towards large monitoring area of the Earth's surface quickly and efficiently. In general all people interested in rare and extreme events such as earthquakes, volcanic eruptions, and glacier surges). So, if we want to capture these events and their natural variability, it's mandatory to allow the global access to make easy data collection and analysis. [1], [13].

IX. DATA COLLECTION AND ANALYSIS

Currently, one of the most famous characteristics of IoT is the increasing inter connectivity among general things or objects, a number of interesting services or applications are emerging. Still, so far many of the existing IoT applications are still highly dependent on human beings for cognitive processing. The future IoT will be a cognitive IoT with large numbers of various interconnected devices, these generate a massive data in an explosively. The data we collect may not have any value, so data analysis, interpret, understand is mandatory now to get a valuable and beneficial information with respect to base data [1], 14]. Data streaming from the spacecraft in current active NASA mission approximately be 1.73 GB gigabytes. The remote sensing data collected by a single satellite data center are dramatically increasing by terabytes per day. Data collection from sensor is difficult in some places, so using a passive microwave radiometry to collect the data, then, analyze it can improve our lives and help build a smart society. Data collection from cars, on a wide area, might be utilized to prevent traffic jams. To materialize such smart systems, it is needed to collect data from these smart things with sensor or materials depend on their reflection as a microwave radiometry using synthetic aperture or any other L-band techniques. The important thing is how to collect the data from a huge number of things or from a huge area with low cost and short range such as rural areas or desert or sea to predict any disaster. This is a future concern towards a global system using satellite communication to collect a data from some area not included any sensor. That might be a significant challenge to realize a smart society. [15] The novelty of future is how to get the wisdom from data as known as DIKW pyramids which is the term refer to (Data, Information, Knowledge, Wisdom) hierarchy is ably presented in Sharma (2004) This term is refers to a class of models for representing the functional relationships between **d**ata, **i**nformation, **k**nowledge, and **w**isdom.

Typically information is defined in terms of data, knowledge in terms of information, and wisdom in terms of knowledge" as shown in figure of DIKW Hierarchy [16]:

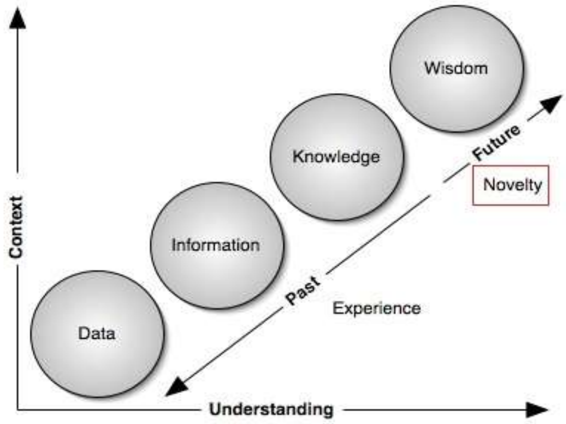

Figure (7) hierarchy of DIKW

Satellite collects data from sensor or the reflected signal from passive microwave radiometer and sends the data to ground stations or any other cloud station, which manage and analyze the data from these sensor based on their applications to get a valuable image. The important role of synthetic aperture radiometry is how to collect data from areas with inadequate network infrastructures where the ground network facilities were destroyed. This will optimize the amount of data and reduce the delay and time for processing to achieve an efficient data collection from numerous sensor or nodes or scanned microwave areas. [1] The radiometric techniques using satellite L-band will be an alternative generation for data collection because the data are now rapidly expanding in all science and engineering domains, including physical, biological and biomedical sciences, in both directions hardware and software. In fact, for decades, companies have made business decisions based on transaction data stored in relational databases.

Big Data mining in satellite communication offers opportunities to go beyond traditional relational databases to rely on less structured data especially when there are no sensors. This will be a step one towards an integrated data management system (Global) using satellite and radar techniques as shown in figure (8).

Figure (8) Future data management system

X. GLOBAL MONITORING FOR ENVIRONMENT AND SECURITY

Global Monitoring for Environment and Security (GMES) is the European project established by Europe for Earth Observation. The main operation of the GMES space component covers the space and ground. The ground division related to space data comprises tasking, storage, processing and acquisition. This program will provide accurate and easily accessible information to improve the management of the environment. Global Monitoring for Environment and Security (GMES) is an initiative aimed at streamlining European activities and funds in the field of Earth observation. This project included three main components which are:

1- Global Land. Managed by the European Commission's Joint Research Centre, Global Land produces biophysical parameters on a worldwide scale.
2- Pan-European continental land which produces high resolution information sets on the main land cover types.
3- Local land: focuses on "hotspots" which are prone to specific environmental challenges like such as flooding.

Earth observation using satellite radiometric techniques (including airborne systems) is a future mission to ensure the long term collection and operational delivery of high resolution measurements as shown in figure below (9) [17]

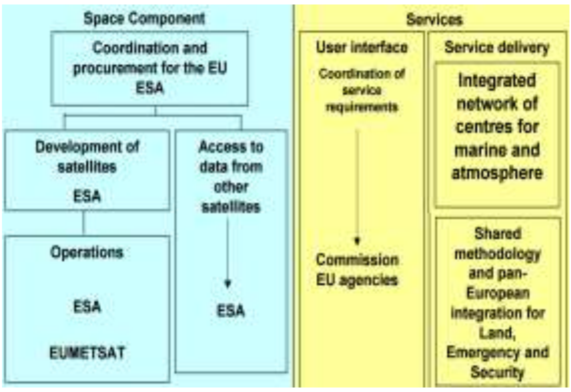

Figure (9) Technical implementation of GMES

It might be also useful in security issues such as border surveillance against attacker or terrorism in a different areas and countries. A large amount of data has already been collected and analyzed, both at national and international levels. GMES included four steps missions, first mission will provide information for all domains for GMES day and night radar imaging from land and ocean services.

The second mission will convey high resolution imaging for land services and 3rd mission will provide services for global land monitoring. The last mission will provide data for atmospheric composition monitoring from geostationary and orbits. The space part is a pre-operational stage, serving users with satellite data currently available through the GMES Contributing Missions at international levels. These four missions consist of:

A- Deployment and operation of a European satellite system for a sustained 20-year period.
B- A robust ground sector managing the mission and generating products through a distributed system.

The resulting from GMES will bring a wide range of benefits to many fields of society as shown in the first parts such as natural resource management, water and security. Also will provide a great geo-graphic coverage of the state and trends of key environmental limitations. Businesses and citizens will also benefit through innovation and motivations to apply a new practical application based on this information. This change will transfer us gradually from regional monitoring system to the global monitoring system. Simply the data collection can be broadly classified into; land, marine and atmosphere information to ensure the systematic monitoring at regional and global levels. Second is the climate change information to support monitoring issue to calculate the effects of climate change and assessing mitigation measures. Also the emergency and security information which providing support in the event of emergencies and humanitarian aid needs, in particular to civil protection authorities (i.e. sea surveillance, border control, global stability) as shown in figure (10) [18]

Figure (10) Global monitoring system

XI. CONCLUSION

The future mission is to establish a new global data management system, which is supported by the groups of international teams working to develop technology based on international regulations. The resulting system of cooperation provides an international mechanism to broaden the exact and hidden value of these data into vital information for society. Big data and the analysis from SMOS and MIRAS are the challenges to space Industry towards a new generation of earth observation. The satellite collects data from the sensor or the reflected signal from passive microwave radiometer and sends the data to ground stations or any other cloud station, which manage and analyze the data from these sensor based on their applications to get a valuable image. The step forward for future mission is to use of microwave radiometers will be considered essential for high resolution. In spite of high performance computer systems, but still remain considerably challenging with big data issues. The large scale monitoring is our future task to implement a new data management system to convert from regional to global one by a different global space and airborne projects such as GMES. There is a growing interest in the use of microwave and millimeter wave radiometers for remote sensing applications, due to the need of large antennas and scanning mechanism. Recent and future trend of SAR technologies is described in this paper; the increasing numbers of space borne SARs have been launched during the last decades. We have presented the recent trend and development of synthetic aperture radiometry and related techniques with the specifications of airborne and space borne SAR.

The important role of synthetic aperture radiometry is how to collect data from areas with inadequate network infrastructures where the ground network facilities were destroyed. There is no doubt that the existing techniques are so limited to solve big data problems completely. Finally the opportunities are followed by challenges, more data become available from international civilian satellites and as scientific demands become greater with the use of these data.

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