A Cognitive Research Tendency in Data Management of Sensor Network

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Abstract

In today's World sensor networks offer various opportunities for data management applications because of their low cost, reliability, scalability, high-speed data processing, and other versatile advantageous purposes. It is a great challenge to organize data effectively and to retrieve the appropriate data from the large volume of various data sets in ad-hoc network databases, mobile databases, etc. The sensor network is necessary for routing of data, performance analysis of data management activities, and data incorporation for the right application. Data management involves intranet and extranet query handling, data access mechanism, modeling of data, different data movement algorithm, data warehousing, and data mining of network database. Additionally, connectivity, design, and lifetime are important issues for sensor networks to perform all data management activities smoothly. In this paper, we are trying to give a cognitive research tendency of Sensor network data management in the last two decades considering all the challenges and issues of both sensor network database and data management functions using Scopus and Web of Science database. To analyze data, different assessments are done considering various parameters like author, time, publication and citation number, place, source, document separately for Web of Science and Scopus database in global perspective. It is noticed that there is a significant growth of research in data management for sensor networks because of the popularity of this topic.

Keywords: Sensor Network, Data Management, Research Trend, Scopus Database, Web of Science Database

1.Introduction

Sensor Network is composed of versatile types of small, powered sensors which are capable of sensing, communicating, and calculating specific functions in the different architecture of the network. All the sensors are located compactly in a monitored region [1]. Sensor nodes are required to perform measurement of physical characteristics and to store the result in the remote systems. Now a day, the latest technologies are being used for systematic sensor data management in the advanced growing field of the sensor networks [2] [3] . In the last two decades, sensor network becomes an appropriate solution for a frequent number of applications like environmental information processing, health care data transformation, agricultural information usage, the corporate system controlling, and many others [4][5]. For all of these types of data and information related functionalities, network database system is becoming popular day by day in the sensor network.

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The main objective of data management is to isolate the logical view and the physical view of data in the sensor network [6]. To systematize and supervise predictable information from the experimented data as well as answering queries from various user applications, the sensor network data management system is necessary [7] [8]. Managing sensor web data, data ingest, organizing temporal and spatial data, statistical modeling of sensor data, data exploration analysis and visualization, managing data uncertainty, data interoperability, query processing, and data security are the different activities of data management in the sensor networks [9] [10]. Sensor data, view node, synchronization of nodes, and queries are the four components to be considered for data management smooth operations in the sensor network [11] [12]. There are versatile types of data management challenges like the organizational information, handling conflicts, infrastructure designing, querying, and trustworthiness of information in the sensor networks [13].

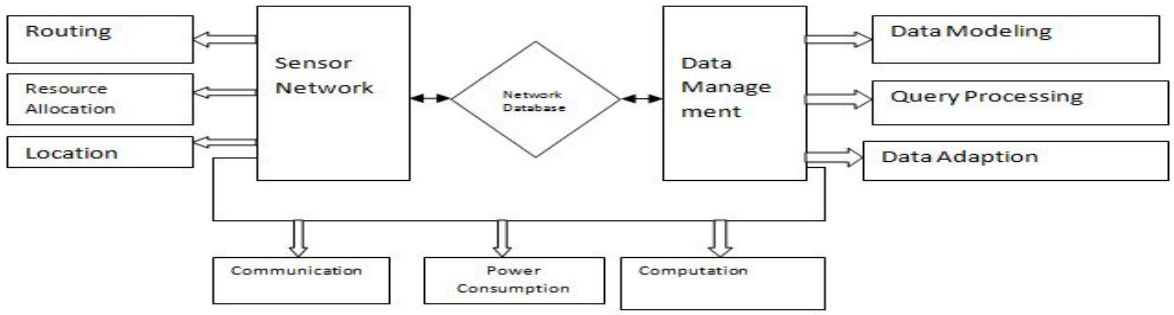

Figure 1: Block Diagram of Sensor Network Data Management System.

To obtain real-world data, we have to extract and merge data from the network database system primarily [14]. But new data adaptation, energy efficiency for intranet processing, and implementation of data processing for the exact data model and query language are our main concerns for sensor network data management schemes [15] [16]. Additionally, routing, query optimization, resource allocation, and deployment should be taken as important parameters for this purpose [17] [18]. So, in short communication, power consumption, and computation are the three main factors of data management in sensor network [19].

2. Background Study

Sensor Networks can create and develop a large volume of data as data is constantly formed and stored in the network database system [20]. There are different types of guidelines already available in the field of the Internet of Things and power management for big data analysis purposes [21] [22] [23]. It is noticed that distributed hash table routing and data management protocol are designed for sensor network. In the environmental data management field, integration of Graphical Information System (GIS) based data model on real-time and sensor web service standard are a better approach [24]. With the help of the semantic web, aggregation, enrichment, and management of data can be conducted organized way in the sensor networks [25]. In case of the sensor networks, the energy efficiency of node and space constraint, query optimization rules for data management in-network databases are also being considered [26] [27]. Quality based framework for sensor data optimization techniques is also proposed in this field. In order to organize and process health data for sensor data management, protocols are designed using a cloud computing mechanism [28]. We have noticed that the general framework for sensor data management is designed considering the speed of data retrieval and security issue [29][31-33].

3. Analysis of Research Trends in Data Management of Sensor Network

In this section, We will observe how the research field of data management in sensor networks has been improved day by day systematically, technically, and in an innovational way. The emerging research trends in this field are

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also discussed based on research topic keyword, year, source, document, and so on [30]. We are trying to analyze and demonstrate the total link strength and research topic analysis of key terms in this area. In order to do this various types of experiments are performed to analyze data taking the last two decades of research work of sensor network data management. For the data analysis part, we are using Scopus and Web of Science databases separately.

3.1 Title and Abstract based research analysis of Data Management in Sensor Network (DMSN)

A deep-level experiment of research in the field of DMSN illustrates all application fields [28] and interrelated research of this area. The experiment is performed taking all data from the Scopus database for research in the last two decades using VOSviewer software, which is shown in Figure 2. Eminent cloud depth can be seen for data transmission, attack, simulation, energy, data delivery, encryption, authentication, confidentiality, key, overload in the sensor network domain. On the other hand, server, module, service, internet, person, platform, mobile device, knowledge, behavior, and other parameters are enormously interconnected to the data management systems[34-36]. One of the important parameters is energy efficiency which is internally correlated with energy consumption, cluster, and reliable data delivery. Additionally, the clustering technique is connected with mobility, energy, and sensor network.

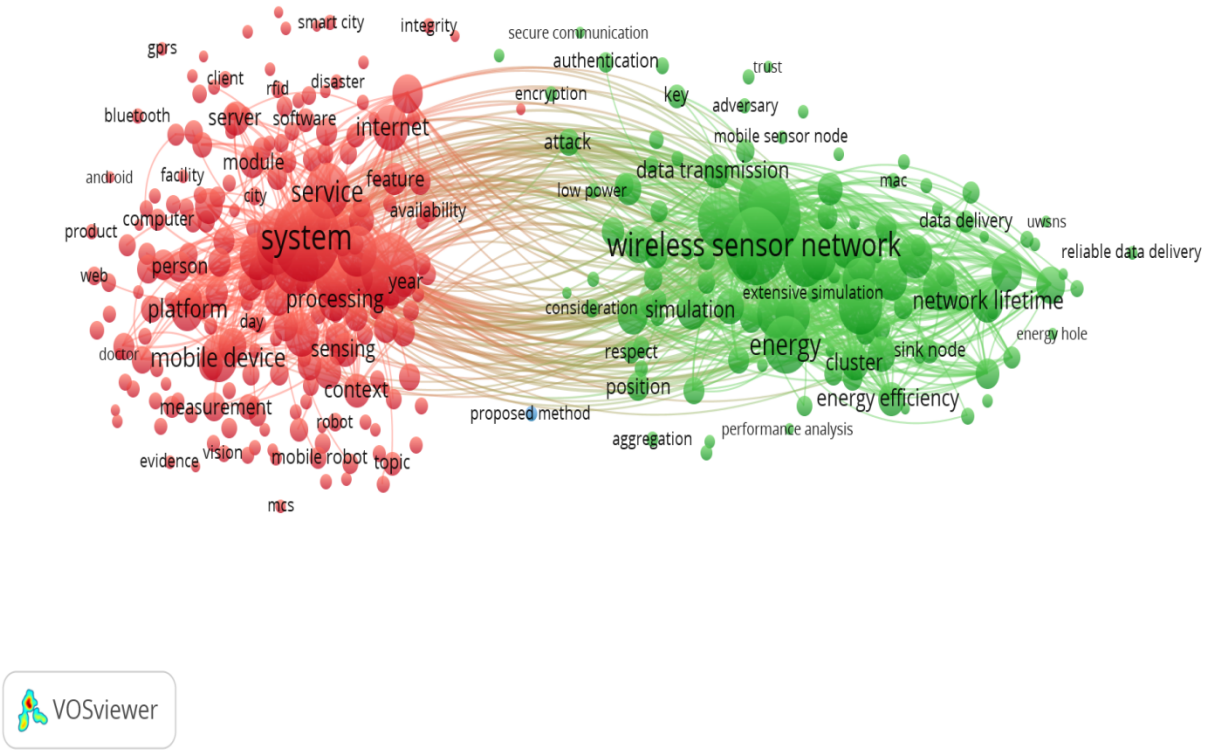

Fig-2: Cloud depth of research on Data Management in Sensor Network based on title and abstract

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3.2 Worldwide Analysis of Research in Data Management of Sensor Network

VOSviewer experimental data from Figure 3 illustrates that China, the USA, and India have mostly participated in worldwide research in this title research field. Researchers in Australia, China, Canada, South Korea, and India have significant collaboration with American researchers in this research area. USA, Canada, South Korea, and India have tied with Chinese researchers in DMSN. On the other hand, the USA, China, South Korea, Thailand, Oman, and Egypt have remarkable research prospective with Indian researchers in this DMSN field. Additionally, USA, China, and Indian researchers work with South Korean researchers in this domain. Germany, Pakistan, Jordan, Taiwan, Oman, and Egypt have participated in research activities in this research field[37-39].

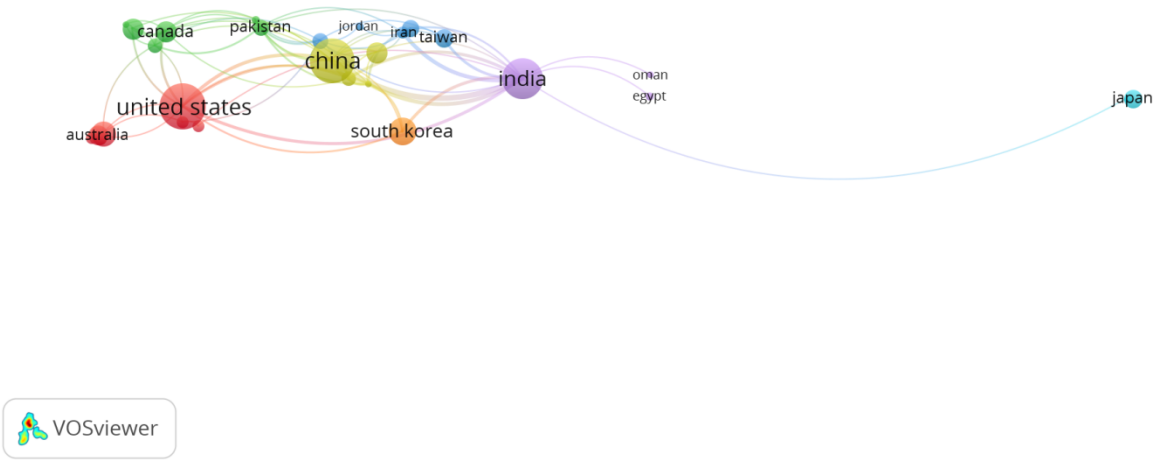

Fig-3: Country Based research Trends in Routing Protocol

The following experiment was conducted to check the international connection of research in DMSN and it was noticed that 38 countries from the world have attended research associated with this area. Out of these 38 countries, only one country USA has more than two hundred (200) publications and 5816 citations which is the highest number of citations in this research field. Another two (02) countries India and China have more than one hundred publications in DMSN and above one thousand citations. South Korea and Germany have more than fifty (50) numbers of publications each in this research field and the rest of the thirty-three (33) countries like Canada, Italy, United Kingdom, Taiwan, Australia, etc have below fifty (50) numbers of publications in this research area. So, the American researchers produced the highest number of citations and publications in Data Management of Sensor Network (Table-1).

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Table-1: Global analysis of Research in Routing Protocol in WSN based on Country, Document and Citation (Source-Scopus Database)

Serial No	Country	Documents	Citation	Total Link Strength
1	India	164	1245	60
2	China	198	2780	46
3	Turkey	6	396	33
4	USA	215	5816	27
5	Iran	16	114	17
6	Canada	46	1610	16
7	Hong kong	21	1133	13
8	Pakistan	25	257	13
9	Saudi Arabia	26	279	11
10	South Korea	75	865	11
11	Spain	24	751	11
12	Italy	44	495	9
13	Taiwan	35	257	7
14	United Kingdom	46	1421	7
15	Germany	64	485	5
16	Viet Nam	8	36	5
17	France	30	1065	4
18	Portugal	15	106	4
19	Lebanon	6	193	3
20	Australia	39	714	2
21	Jordan	7	122	2
22	Malaysia	16	214	2
23	Singapore	17	554	2
23	Thailand	8	218	2
24	Egypt	7	41	1
25	Japan	35	310	1
26	Oman	5	8	1
27	United Arab Emirates	16	186	1
28	Algeria	6	27	0
29	Austria	8	78	0
30	Belgium	8	178	0
31	Brazil	13	55	0

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32	Finland	11	165	0
33	Greece	13	253	0
34	Ireland	8	353	0
35	Poland	5	17	0
36	Sweden	9	99	0
37	Switzerland	12	423	0
38	Tunisia	14	59	0

3.3 Year wise analysis of Research in Data Management of Sensor Network

An experiment is conducted with the help of the Scopus database, for the last two decades. The following Figure 4 undoubtedly states that the research significantly started from 2014 and subsequently there has been a stable rise in research publications each year. The emergent publications have enlarged clearly in the last ten (10) years which obviously explains that a large amount of work is accomplished in this field. There is approximately fifty-three (53) research papers that can be acknowledged in the Scopus database, every year. In these ten years, the maximum number of research article citations is visualized in 2014. Another significant point is that a great portion of research work in Data Management of Sensor Network was done in 2014, 2015, 2017, 2018, 2019, and 2020. An IEEE communication survey and tutorial paper on distributed mobile sink routing for sensor networks which was published in 2014 has been referred in different research paper of 2018, 2019, 2020.

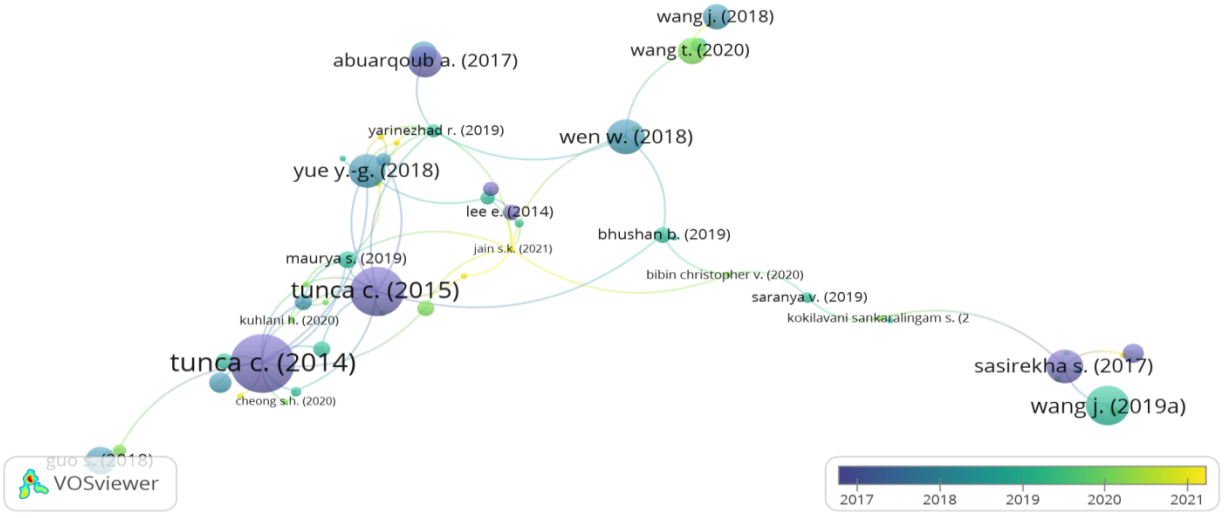

Figure 4: study of year wise citations of research development in DMSN

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3.4 Source based analysis of Research trends in Data Management of Sensor Network

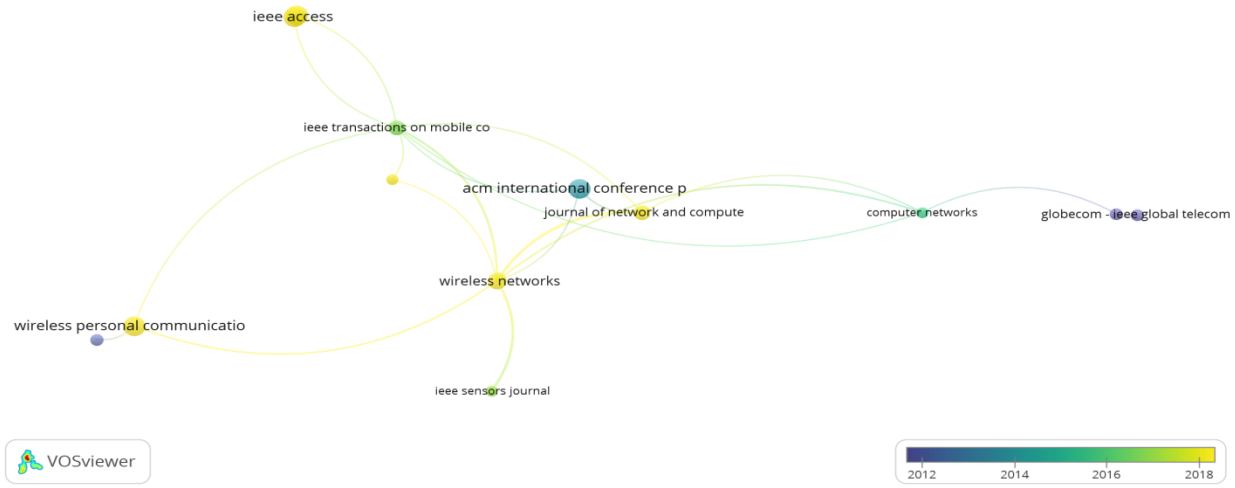

Figure 5: Source base analysis of research in DMSN

3.5 Analysis of Research in Data Management for Sensor Network using Web of Science Database

With the help of the Web of Sciences database, an experiment is conducted on research trends in Data Management of Sensor Network for the last fifteen years from 2006 to 2021. The evaluation gives a variety of research articles, articles in diverse journals and conferences. Figure 6 certainly illustrates that nowadays, there is an emerging rise in DMSN-related research works. In this Figure 6, it is evidently noticed that there is the maximum number of publications occurred in 2009 out of the last fifteen years (2006 to 2021) in this research field.

A very interesting point is that there was no research work performed in 2008 and 2015 on this topic (Source: Web of Science Database. In 2019 and 2020, there was only three research works published in Data Management of Sensor Network separately and two research papers were published in each of 2010, 2013, and 2021. Additionally, it can be stated that in each year of 2006, 2007, 2011, 2012, 2014, 2016, 2017, and 2018 only one research paper was published on this topic.

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Figure 6: Research trends on Data Management in Sensor Network (Year Vs. No of publication)

Figure 7 shows the research development in the Data Management of Sensor Network in the fifteen years (2006 to 2021) based on years and number of citations. In this figure, we can obviously observe that there is an exponential growth of citations in this research area. This indicates that Data Management in Sensor Networks is becoming a major field in the regular research area progressively as the citation number of this topic-related research paper is rising.

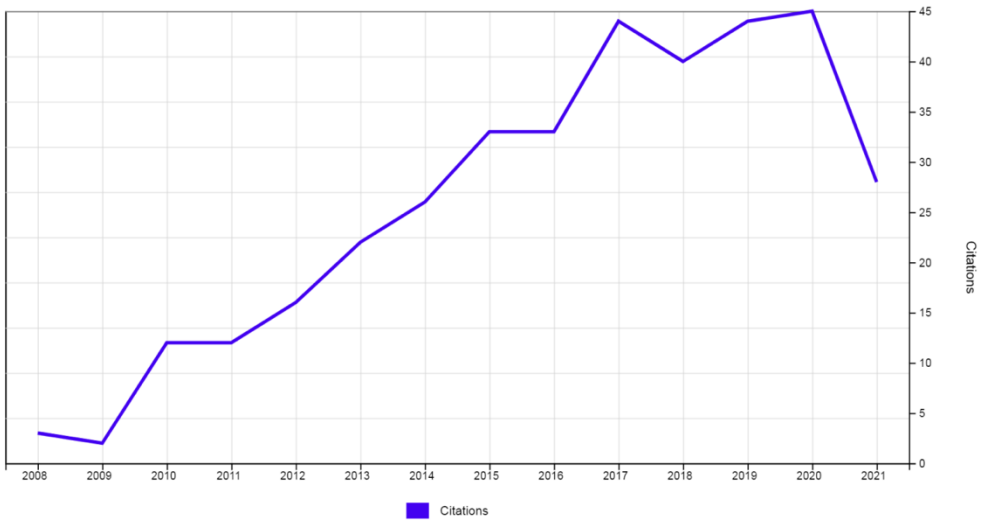

Figure 7: Research Trends Routing Protocol in WSN-Year vs. Citation (Source: Web of Science)

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Let us consider the following table-2 which shows the increasing development of research trends in Data Management of Wireless Sensor Network for the last fifteen years (2006-2021) with the help of the Web of Science database. In the following table, we have chosen randomly ten research articles of different years and it is observed that the citation number of each research paper is radically growing in the last five years. This indicates that the research range in this area is increasing significantly in the last five years.

Table-2: Analysis of research trends in Routing Protocol of WSN in last five years (2017-2021), (Source-Web of Science Database)

Paper In Year	Topic	Citations						
		2017	2018	2019	2020	2021	Total	Average
2006	Current Trends in Environmental Data Management	1	0	1	1	1	4	0.8
2007	Load Balancing of Mobile Sensor in Wireless Sensor Network	3	0	1	1	0	5	1
2009	Survey on Mobile Agent Application	1	2	0	1	1	5	1
2009	Environmental Sensor Network	8	10	8	1	1	28	5.6
2011	Data Acquisition and Replication in Mobile Sensor Network	0	2	0	0	0	2	0.4
2014	Survey on Data Management in Mobile Sensor Network	17	12	12	4	4	49	9.8
2017	Clustering and Management of Mobile Sensor Network	14	13	11	14	6	58	11.6
2018	Time estimation based on Data Fusion	0	1	4	2	2	9	1.8
2019	Fake Data Detection in Ad Hoc Network	0	0	5	6	1	12	2.4
2019	Energy efficient clustering Routing Protocol for Sensor Network	0	0	2	11	4	17	3.4

4. Conclusion

Data Management in Sensor Network (DMSN) is the most up-to-date research topic in various newest networking fields in twenty-first century. The purpose of Data Management in Sensor Networks is to perform query optimization, query processing to manage data of network database. In this research paper, a scientometric analysis of recent research growth in data management of sensor networks is discussed. In order to do this, various types of assessments are conducted with the help of Scopus and Web of Science databases separately. We have used the Vosviewer tool for data analysis to show research trends in the last two decades taking different parameters like

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the author, year, source, document, keyword of our research topic 'Data Management in Sensor Network'. The experimented outcomes are very encouraging for the researchers working in the area of DMSN.

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