International Journal of Web-Based Learning and Teaching Technologies
Volume 17 • Issue 4 • July-August 2022

A Novel Approach for Semantic Web Application in Online Education Based on Steganography

Gurunath R., CHRIST University (Deemed), India
Debabrata Samanta, CHRIST University (Deemed), India
https://orcid.org/0000-0003-4118-2480

ABSTRACT

Semantic Web technology is not new as most of us contemplate; it has evolved over the years. Linked data web terminology is the name set recently to the Semantic Web. Semantic Web is a continuation of Web 2.0, and it is to replace existing technologies. It is built on natural language processing and provides solutions to most of the prevailing issues. Web 3.0 is the version of the Semantic Web that caters to the information needs of half of the population on earth. This paper links two important current concerns, the security of information and enforced online education due to COVID-19 with Semantic Web. The steganography requirement for the Semantic Web is discussed elaborately, even though encryption is applied which is inadequate in providing protection. Web 2.0 issues concerning online education and Semantic Web solutions have been discussed. An extensive literature survey has been conducted related to the architecture of Web 3.0, detailed history of online education, and security architecture. Finally, Semantic Web is here to stay and data hiding along with encryption makes it robust.

KEYWORDS

COVID-19, Encryption Data Hiding, Linked Data Web, NLP, Online Education, Semantic Web, Steganography, Web 2.0, Web 3.0

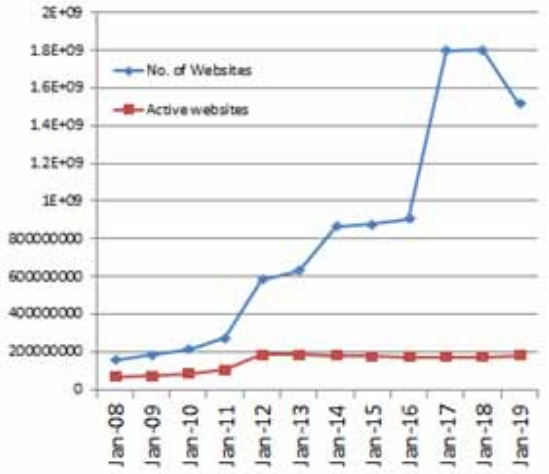
INTRODUCTION

The information-sharing through forms and documents on the web started in the 1990s that could be understood only by human beings. Computers till recently were called dumb machines because that could process the data in some manner rapidly, however, it could not understand the contents of the documents on the web. The latest version of web technology is called Semantic Web or Web 3.0, which can understand the web content and accordingly, processed by the machines. Earlier to this, Web was called the "Web of documents" and now it is termed as "web of data"; a kind of significant makeover achieved, and paralleled intelligence built into it. Therefore it is an extension of current Web.

Reasons for the development of the Semantic Web may be several. Automating the searches through virtual agents is the need of the hour, for example, Google Assistant, Amazon Alexa, iPhone's Siri. Curating the contents (Personalization) of the web by agents is been introduced. Since the Web contains enormous amounts of data, and highly difficult to track them everything. Good-old search

DOI: 10.4018/IJWLTT.285569

Figure 1. As on 2019 the total number of websites and active websites



Year-wise	No. of Websites	Active Websites
Jan-19	1518207412	182185876
Jan-18	1805260010	171648771
Jan-17	1800047111	172353235
Jan-16	906616188	170258872
Jan-15	876812666	177127427
Jan-14	861379152	180067270
Jan-13	629939191	186821503
Jan-12	582716657	182441983
Jan-11	273301445	101838083
Jan-10	206741990	83456669
Jan-09	185497213	71647887
1-Jan-08	155583825	68274154

engines fail to retrieve accurate information from the web. Semantic Web search engines are smart enough to retrieve needed information. Reuse of data on web was tough earlier, now the new version discovers and links every relevant data from different sources, and creates a data map of relation so that the existing data can be utilized in a much meaningful way. Isolated databases can now be used and a piece of new knowledge can be discovered(Padmanabhan, 2020).

The aim to build the semantic web is to provide a system that facilitates with machine-understandable web data, metadata, and other information objects. To achieve this, newest buzzword technologies namely, AI, NLP, Natural Language Understanding have become part of semantic Web technologies(Trending-topics, 2018).

This paper presents details in different parts pertaining to Web 3.0 Architecture, Current Web Status, Semantic Web Challenges, Need for Semantic Web, Semantic Web and Online Education, and Applications of Semantic Web Steganography.

Status of Current web

As per (Technology, 2020), more than 2.5 Quintillion (Approximately, 2273736 TB), bytes of data,has been generated every day.By 2025, it's projected that 463 Exabyte of data will be produced each day globally (Forum, 2019) – that's the equal to212,765,957 high volume CD's per day!

The ratio of Active and inactive websites are 15:85%**(Huss, 2020)**, that means, out of all websites very little websites are active. The graph and the table in **Figure 1** illustrate the present status of the web.

Challenges on Current Web

The maximum data generated through online (Web 2.0) is of flat text format; this can be easily consumable by human beings(Bessis, 2011), meaning that it is easily understandable. However, it is very difficult for the machines to process and understand. Since, there is no provision for the machines to react on the data, in the framework of the goals of the user. Duplicate data(Baker, 2015) on Web is another major challenge; about 30% of total volume of the data on websites is redundant.

Redundant data is very much required and it is in the form of HTML tags and attributes, and most other repetitions happen due to the user data distribution. The Web is so huge that the repeated information (Valk, 2019)is scattered on the Web. This is due to multiple URL's, showing the similar content. The search engines are incapable of recognizing those URL's as duplicate. Thereby, people start linking to different copies of the same content. The data generated upon the query on the Web is not accurate, because, it provides information as document; rather than the data. Security and privacy threat is common since sharing information on social media network might result in abuse of individual information. To sum up, the explosive growth of the Internet and data generation cannot handle by Web 2.0.

NEED OF SEMANTIC WEB

Semantic Web is the answer for many questions that are raised out of the Web 2.0. The newest concepts include (Bessis, 2011), the blend of deductive databases, expert systems, knowledge based systems along with Semantic Web and its associated applications are much needed to cover the issues mentioned above. The Web 3.0 has the facility of reducing the repeated information and dummy information. It lowers the overload of information as against Web 2.0. Other features such as: automated interoperability, sharing knowledge, avoiding unwanted information while surfing and intelligent search engines are part of Semantic Web.

Overview of Semantic Web or Web 3.0

The father of the World Wide Web is Sir Tim Berners Lee(Berners-Lee, 2020). He structured today's everyone's breathe WWW in the year 1989. He was the founding director of W3C. He is the creator of all the versions of the Web. Semantic Web or Web 3.0 is the current version of Web. The idea behind the semantic web is to link not only the documents but to identify the meaning of the documents as well. It is the web of meaningful data. Web 3.0 is the extension of Web 2.0 and has intelligence built into it. Previously, the user used to carry out a lot of process on the web to retrieve the required content whereas the present Web has a sophisticated mechanism to do the same by its own.

Semantic Web is expanded World Wide Web (Herman, 2009). The old definition of the web is, - it is the network of web pages or documents. However, the newer Web extended the meaning to - a network of data. There are the majority of application areas used in semantic Web such as data integration - the data from several sites with various forms can be clubbed to make a meaningful sentence, Seamless Application - a mode of working that appears as an application installed locally even though access to the remote application, an improved search engine capabilities - that provide proper resource discovery and classification; cataloguing facility - to describe and relate the contents; clever software agents - for exchange and sharing of knowledge; content rating, and so on.

EarlyWeb Technologies

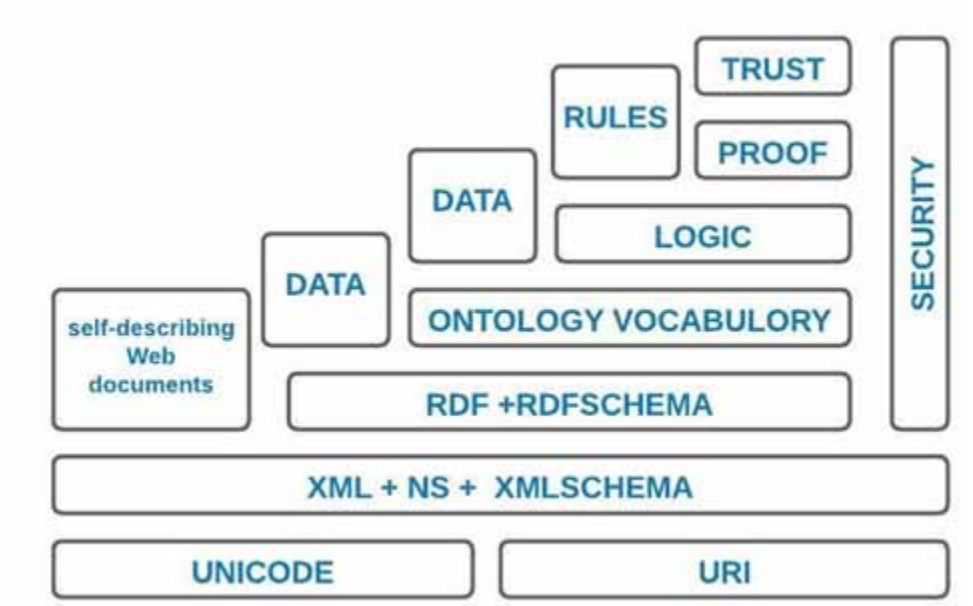
Web 1.0

It is the Web, websites contained read-only or static data used for information sharing. The main concern in this technology is to connect information rather than people. Since it was not interactive technology, normally the data stored could only be viewed by the users, and most of the contents stored were owned by the individuals. The main language to work with was HTML. One of the example is Britannica online(Encyclopædia Britannica, 1994) - maintains static information of more than 120,000 articles, TED conference – contains videos of famous people, etc.

Web 2.0

It is called Social Web and interactive. The data could be downloaded or uploaded. People can communicate with others through social networking, blogging, and messaging applications.Users

Figure 2. Web 3.0 / semantic Web Architecture



of Web 1.0 are mere spectator; they could only have the opportunity of reading the contents posted by the site owner. However, Web 2.0 users able to read, comment, upload the contents to the website(Krishnamurthy, 2008).To work with the technology web applications such as XML, RSS, scripting languages, etc. are used. Used for interactive advertising. Ex. Wikipedia, Facebook, Twitter.

Web 3.0 / Semantic Web

The dissimilarity among the current web and Semantic web lies in the meaning of the document. When tries to search for a keyword in the Web 2.0 it extracts only the links pertain to it, however, the semantic web gives the meaning of the keyword and links as well.

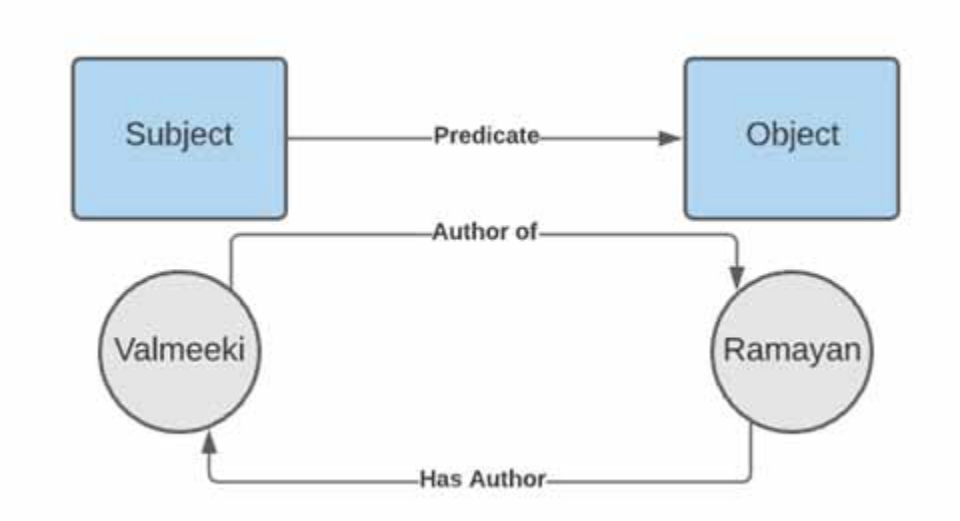
The layers given in the Figure 2 represents the architecture of the Semantic Web. The components Unicode, URI, XML, Namespace and XML Schema are fully standardized and part of Web 2.0. The layers RDF, RDF Schema Ontology are standardization in progress and the upper remaining layers are still under experimentation.

HTTP is a common protocol that connects heterogeneous operating systems and web applications together on Web. Semantic Web uses HTML; however it cannot penetrate some firewalls. Therefore, Web 3.0 uses XML-based SOAP protocol to allow communication among diverse applications(Rudman, 2015).

UNICODE is the most used technique for internationalizing the characters of any language, later these language characters can be digitally stored processed across online applications. It is used by XML to describe and identify characters. XML is Extended Markup language, used to convert any documents into a standard format and can be directly used by applications. XML and HTML both can intermingle. Users can create their one custom tags to define the data in the XML and HTML can only use the standard tags(Rudman, 2015).

RDF (Resource Description Framework) - Developed by WWW consortium introduced in 2004 and defines Web metadata and helps readers to explore the page, search engines to find the page. RDF describes the contents of the web or web resources. It provides an ability to readily connect and exchange data with one another. It builds a knowledge representation data model upon

Figure 3. RDF Triplet showing the relationship between Subject and Object



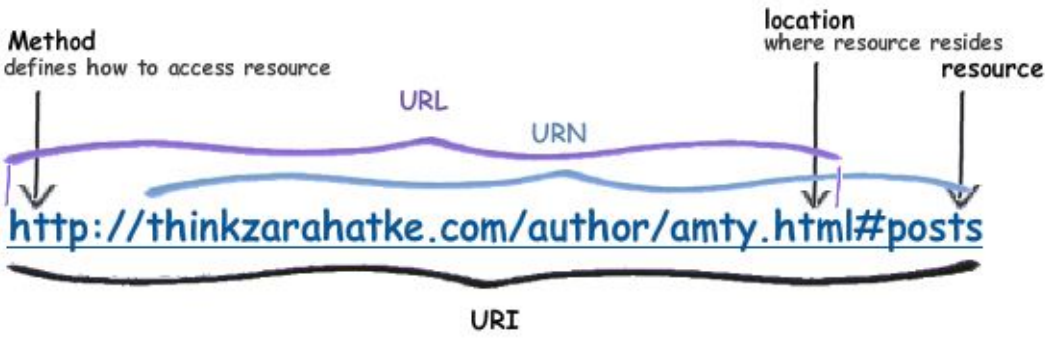
XML and relates Subject and object via verb/predicate. RDF and XML are alike when querying documents on the web; however, RDF not only retrieves information but also retrieves 'meaning' of the documents. This feature is absent in XML. RDF model takes knowledge from the web and RDF segments knowledge into machine-readable separate parts and called "triplets"(PubChem, 2014). RDF knowledge representation is shown in the Figure 3.

RDF schema - This defines object-oriented concepts such as classes, class inheritance, and class properties. It is language; describes vocabulary for RDF. It defines the range and domain properties that, it shows how property links a subject to an object.

URI, Uniform Resource Identifier is a way of RDF to identify the resources on the web by specifying subjects and predicates. Once the resource is identified, then the URL, Universal Resource Locator, used to locate it by using a specific website address on the web to acquire Resources (Figure 4).

Ontology Vocabulary – In Semantic web, to represent Rich and Complex structures of knowledge and its relationships, ontology has been adapted. It suggests a concise and methodical way of defining the meanings of web resources. Ontology gives a clear picture of the relationships of the concepts, things and their properties of the mentioned web resources and puts these in a nested or chronological

Figure 4. Source (ENIGMA, 2014), URI Example



order of elements(Nandini, 2014).A specific language is built for Ontology process called Ontology Web Language, OWL that enables machines to understand and process the information on the web in a guided way. OWL is a combination of markup languages aimed to help applications to process information ontological manner. OWL- has more capable than XML, RDF, and RDFS in terms of higher machine-understandable, a larger collection of vocabulary terms. Capacity to retrieve information and later comprehend the meaning is the core of semantic Web; OWL facilitates these in a greater way(Semantics, 2020).

Query Language - Every data model requires a query language to access the data. Oracle, SQL, XML, XQuery, DB2, etc., are based on relational models for data retrieval. Semantic Web model uses SPARQL query language for RDF data, and return the resources in the form of URI's or group of triples(Subject, predicate, and object)(Guo, 2020).

Logic- it is the capability of OWL language; these include classes and object properties, data range constraints, cardinality constraints, and several distinct properties. OWL ontologies have query "rules" that are expressed by Semantic Web Rule Language (SWRL). The rule has two portions body (the antecedent of rule), and head (consequent of rule), that exists as implications. Rules that facilitate OWL ontologies to discover knowledge and specifies how the projected meaning can be read and used(Frey, 2019).

Trust and Proof - This is still challenged for Semantic web, issues related trust and proof continued to be unsettled. To some extent, the Blockchain technology might be impressive. The Proof level performs the rules and assesses together with the Trust level mechanism for applications whether to trust the given proof or not. The proof uses Digital signature to authenticate the information and checks to see that it is valid or not. Trust is built by way creating a web of trust; constructed by experience, following, and spreading trust between web sources(Ruta, 2018).

Semantic Web and Online Education

In the ancient Indian perspective, students learn from human masters from the "Gurukul" era. When time passed, more and more persons were interested in discovering new things, so the accommodation of technology into schooling began. Online education came into being through a variety of modes, including communication through newspaper, radio and television broadcast services, and then the age of online learning came to the present Semantic Web education. People have undergone face-to-face and online/Internet-based education during this period. A number of such advancements in the field of education have been listed in Table 1 up to the new norm COVID - 19 education.

People were connected to online education in average numbers prior to the COVID-19 pandemic. The online platform was used by those who are part of the corporate sector to get trained on par with business needs. Students used to take online-certification as an add-on course along with their regular syllabus via Coursera, NPTEL, Swayam, etc.

With relevant information, analysis, data collection, Web 3.0 will help online educators develop, assist and exchange content for learners. Semantic tools for web metadata assist teachers and students in information management. Web 3.0 OWL and RDF specifications guide implementers to develop new mainstream online teaching applications.

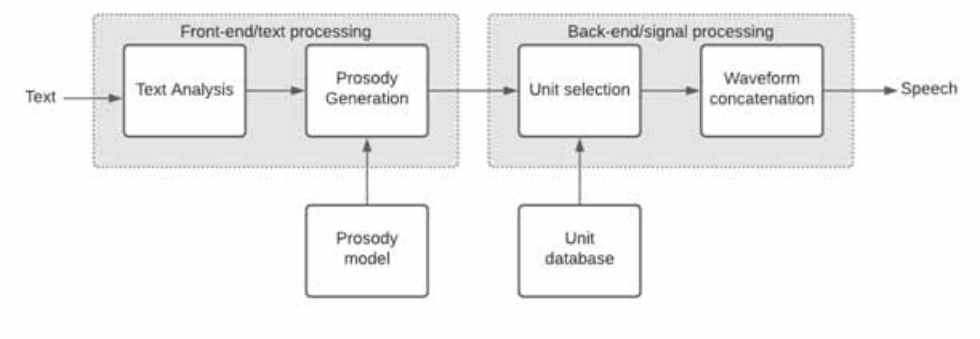
Online learning is a flexible compare to offline, however, both are having their own merits and demerits. Not all learners capable enough to learn through online only. Some might prefer to go for blended learning. The learners, who are successful through the online system, might have an eagerness to equip with the latest trend technologies and fast learning. The main difficulty of online learning is the lack of mechanisms to retrieve content information on the web with respect to the requirement of the user, and user has tospend more time on the web to get the required knowledge. Web 2.0, fails to achieve success in online education. The newer version of WEB, Semantic Web might overcome the drawbacks of the present Web, due to the innovation of machine-understandable technique. The advent of keyword search and metadata search will definitely help students to learn things well. Web 3.0 might be more student and teacher-friendly in the days to come(Shah, 2012).

Table 1. Source - (FERRER, 2019)The Detailed history of Online Education is given in chronological order

Year	Status of online learning	Year	Status of online learning
1728	Correspondence Education in the Boston Gazette Newspaper	1989	• Fist Online degree program offered at the University of Phoenix.
1725	Postal Education system in US	1990	Fist Open source Operating System, Linux built by Linus Torvalds, for the purpose of online learning platform.
1858	The University of London for the first to introduce distance learning degree through its "External Programme."	1991	• Introducing world's first WWW opened for general public for the use of Online Education and for browsing.
1892	The Chicago University offered first Distance education	1992	The first Online PhD program through Electronic University Network, America Online.
1906	• The first School in US to introduce correspondence courses is Calvert School	1994	• First synchronous learning with real time instruction at Cal Campus. • .
1911	• First Correspondence studies department introduced in the Australian University of Queensland.	1996	• Launching of first fully Web based, and accredited university. •
1922	First College to start Broadcast Courses through Radio is Pennsylvania State University.	1997	Virtual University is recognized to provide students with data about online courses at California. The Cooperative Learning Network is created and used by multiple schools as an early (LMS).
1925	• Correspondence courses through Radio Started at University of Lowa with course credit.	2002	• Free Open Course ware project facilitated educational resources a MIT •
1946	Correspondence courses started at South African University.	2009	Online degree courses started by Liberty University.
1953	• Correspondence courses started at University of Houston through Television	2012	MOOC programs are started by Udacity in a massive way in association with Harvard and MIT.
1960	First university of Illinois access Internet system to download course material and recorded lectures.	2018	An era started, to promote Online programs by public universities.
1965	First Correspondence course for physician training at the University of Wisconsin through telephone	2019	First online Bachelor degree by University of Pennsylvania. .
1976	First Tele-courses as well as first virtual campus started at, Coastline Community College.	2020	The COVID-19 pandemic has changed Education forever

Web-based education is most promising and expected to offer many things, namely, tailored learning material, easy to monitor the status of learning, students can discover best-suited services from the web, and students can make suggestions towards improvement. Learning barriers have all been lifted, be it geographical, cultural and techno graphical. There is a vast change in the data communication technologies nowadays correspondingly online education is also gearing up to embrace Semantic Web technology. The new method of Teaching and learning empowers users to share, create, and collaborate contents among online forums, wiki, and social networks. The semantic web has

Figure 5. Siri Method of Text-to-Speech Synthesis



got great potential with regard to online education in terms of privacy and security, choosing tutors, utilization and integration of existing tools, etc. However, certain issues still persist; those are cost, the safety of data, legal and copyright, personalization(Bashir, 2020).

WEB 3.0 APPLICATIONS

iOS Siri is a digital assistant, one of the applications of Web 3.0 that uses recognition technology to talk, based on deep learning techniques. The automated processing of human speech is speech synthesis. It is commonly used for numerous uses, from games and entertainment to assistive technologies. It has recently become an important component of personal assistants online, like Siri. Apple is pushing things forward in the deep learning framework in an on-device dynamic unit selection system. Enabling Siri to have the highest possible Siri voice experience on all platforms. Some of the wide range of human speech is encompassed by the creation of a text into a natural-sounding speech system for a PDA and synthesized using a speech database.

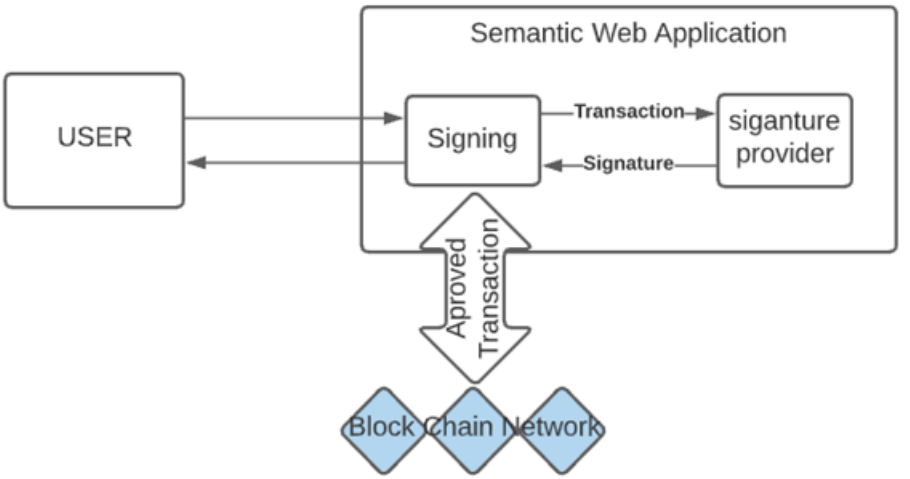
The fundamental issue of unit selection text-to-speech is a set of units that match the input text and the expected objective prosody (TTS). Historically, the mechanism consists of two distinctive parts: the front-end and the back-endas shown in Figure 5. Based on the raw text content, the front end provides phonetic transcription and prosodic information. The Prosody Generation Module predicts values for acoustic features, such as tone and duration. These values are used to select appropriate units. Advanced synthesizers use machine learning skills to discover the relationship between text and speech. This model must be perfected at the training stage of a synthesizer by using a large volume of speech data.

In contrast to the front-end, the backend is mostly language autonomous. It consists of components for selecting units and integrating waveforms. The recorded speech data is segmented into individual speech sections using forced synchronization between the captured sound and the recorded script. This knowledge is then used to create a unit store. The classification is based on two requirements: 1) the units must meet the prosody objective and 2) without audible glitches, the units must be merged at the unit boundary. These two requirements are called the cost of target and concatenation, respectively(Conkie, 2017).

Facebook has invited individuals to create new communities that can grow on Web 3.0. From quizzes and challenges to interactive presents, these individuals have produced 300,000 apps. Through supplying developers with the Facebook API, the company helps developers to stage product reviews and games for their quizzes.

Wolfram Alpha is a platform for computational intelligence where responses can be computed. This platform uses Web 3.0 by extracting knowledge from libraries on the web for users(NLearning, 2020).

Figure 6. Semantic Web Security model



Web 3.0 and Security

Web defense is a method of protecting, detecting and reacting to intruder/attacker attacks and threats. Securing the details on the website and its applications is achieved by authentication protocols. It is possible to use cyber protection and network security interchangeably. The semantic web is an expansion of the previous web, therefore cyber security can also be extended to Web 3.0.

The Figure 6 is the security model adopted in Semantic Web; it uses Block chain networks to process the request from a particular node. The data can be read by anyone and is public on popular open distributed network. The most important thing is writing a piece of information into the black chain network. The terms transaction and digital signature are used with respect the Semantic Web architecture components Trust and Proof. All updates to the Block chain network must be submitted using transactions. The Block chain network determines that a transaction is a valid, only if a valid digital signature is provided. When Application requests something, the user sees it and can approve or reject it. If approves, the transaction goes into the Block chain network(Abou-Nassar, 2020).

Application of Steganography in Web 3.0

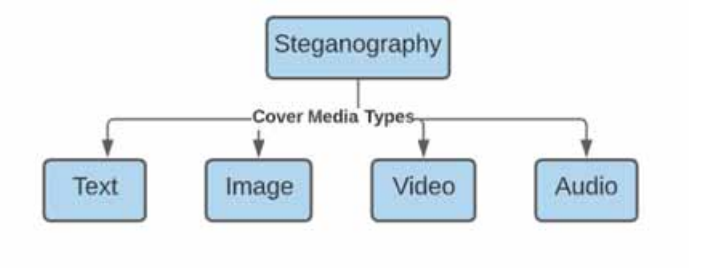
Steganography is a process of hiding secret information into innocent cover medium and sent to the destination via Internet. Cryptography and Steganography used for protecting the privacy of the message with a bit difference.

Cryptography is secret writing and Steganography is hiding secret. There are different types of Steganography based on the cover medium namely, Text, Image, Video, and Audio shown in Figure 7

The steganography process involves two component processes, embedding and extraction shown in [REMOVED REF FIELD]Figure 8. Embedding requires two parameters, one is to conceal a secret message, and the other is an innocent cover medium to embed a message. There are many embedding algorithms, depending on the type of cover medium used and the amount of secret information to be embedded.A Stego medium is obtained after the embedding process is finished, it appears identical to cover medium, and unintended individuals will therefore not find the secret in it.

The Stego media is later sent to the destination via the Internet. The Stego medium is subjected to an extraction process at the destination; the same algorithm is performed in reverse order and the secret is eventually extracted.

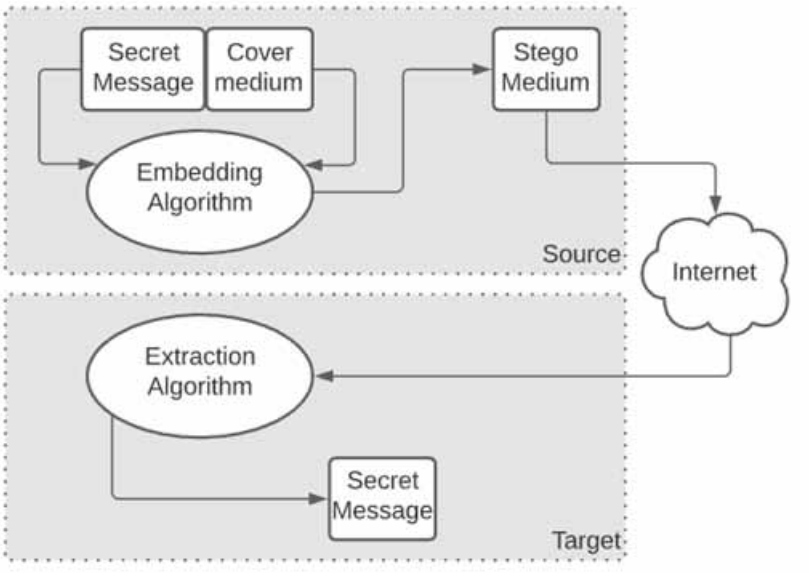
Figure 7. Types of Steganography



Many encrypted systems use encryption mechanisms to protect organizational data; confidential message privacy is covered by steganography. Such messages may be passwords, private and public keys, hidden keys, any server's session credentials, integrity codes, hash or even digital signatures. Because of the compromise in the security procedures, we have seen many security breaches happen in our web environment. As the number of internet users grows every year, at the same time the number of security threats and harm increases by leaps and bounds. Companies spend a great deal on preserving their precious records. In the area of protection initiatives, the research group is working hard to identify new technologies.

The security of Web 3.0 is much more enhanced than the existing Web. The integration of the Black Chain Network along with the digital signature ensures that any transaction is legitimate. If the digital signature is not legitimate, the Block Chain Network will not process the transaction. The newer safety measure would also be much more stable than the Web 2.0. Cyber security is an aspect of information security, so cyber security services used in information security are also a good part of cyber security. Cyber security is nothing but protected data on the Internet. Similar protection steps are followed whether the information is from Web 2.0 or Semantic Web. Encryption is often used to protect the privacy of any data. Encryption alone does not serve the purpose since everybody,

Figure 8. Process of Steganography



including the attacker, knows that the cipher text contains secret data once the cipher text is produced. Steganography can be used in Web 3.0 to fix the problem, so that the encrypted text is inserted into any innocent cover text. Later, hardly anyone notices the classified knowledge exists. Just the sender knows about it and the recipient. To extract embedded cipher text from the cover text, the receiver has all the information. Therefore, any confidential data can be safely sent between the source and the destination in this way.

It not only alters the meaning of data for data protection, but also masks the existence of data from hackers. The key purpose of the steganography method is to cover a vast volume of enciphered and authenticated data independent of the image's scale, proportions and without disrupting the image's visibility. Just as encryption is the built-in authentication choice in most Web 2.0 applications, built-in steganography could be used to protect their data in order to boost Web 3.0.

Nevertheless, we should not rule out the actions of attackers. Even after applying encryption and steganography, they discover that there is a secret by some means. Extracting the secret is not that easy for them in such circumstances. They have to process the decryption of the data, even if they extract it. It is also believed that cryptography and steganography, if used together, will be a robust Web 3.0 security model.

CONCLUSION

Semantic Web Technologies are an extension of Web 2.0. It is offering more human-computer interaction by way of linked data Web. The drawbacks prevailing in current Web technology is been replaced with the solutions. Web 1.0 allowed only the static web pages owned by individuals, and there was no interaction facility with the server, similar to one-way. In Web 2.0, the current Web has got immense popularity because of social networks such as Facebook, Twitter, LinkedIn, etc. This era is called the document web. Sharing information and interacting with people has been habituated by everyone. Even a layman nowadays knows about doing any kind of transactions. HTML is a technical word; however, an illiterate uses it on a daily basis for the exchange of information. The newer Web called Semantic Web, Web 3.0, or Linked data Web. The main drawback of Current Web is, the machines do not understand the meaning of data in the document. The Web 3.0 retrieves not only the documents along with meaning as well. Instead of creating the Web of documents, it creates Web of Data by linking all the relevant data. Web 2.0 services suffered from the available security features, but the paper points out the downside and can become stable application by implementing steganography along with encryption. Steganography as a defense in the area of online education yields much greater protection.

REFERENCES

Abou-Nassar, E. M.-K.-L., Iliyasu, A. M., El-Kafrawy, P. M., Song, O.-Y., Bashir, A. K., & El-Latif, A. A. A. (2020). DITrust chain: Towards blockchain-based trust models for sustainable healthcare. *IoT systems. IEEE Access: Practical Innovations, Open Solutions*, *8*, 111223–111238. doi:10.1109/ACCESS.2020.2999468

Althar, R. R., & Samanta, D. (2021). The realist approach for evaluation of computational intelligence in software engineering. *Innovations in Systems and Software Engineering*, *17*(1), 17–27. Advance online publication. doi:10.1007/s11334-020-00383-2

Baker, N. T. (2015). *How Common is Duplicate Content?* Retrieved 11 15, 2020, from RAVEN: https://raventools.com/blog/duplicate-content/

Bashir, F. e., & Warraich, N. F. (2020). Systematic literature review of Semantic Web for distance learning. *Interactive Learning Environments*, 1–17. doi:10.1080/10494820.2020.1799023

Berners-Lee, T. (2020). *Biography*. Retrieved 11 18, 2020, from W3.org: https://www.w3.org/People/Berners-Lee/

Bessis, N. (2011). *Next Generation Data Technologies for Collective Computational Intelligence* (Vol. 352). Springer. doi:10.1007/978-3-642-20344-2_19

Conkie, A. G. (2017). *Siri On-Device Deep Learning-Guided Unit Selection Text-to-Speech System*. ISCA.

Encyclopædia Britannica. (1994). https://cdn.britannica.com/mendel/eb-logo/b-50-pb5.png

Enigma, P. (2014). *URL vs URI vs URN*. Retrieved 11 21, 2020, from PERPETUAL ENIGMA: https://prateekvjoshi.com/2014/02/22/url-vs-uri-vs-urn/

Ferrer, D. (2019, July 17). *History of Online Education*. Retrieved 11 22, 2020, from The Best Schools: https://thebestschools.org/magazine/online-education-history/

Forum, W. E. (2019, April 17). *How much data is generated each day?* Retrieved 11 15, 2020, from World Economic Forum: https://www.weforum.org/

Frey, S. K. (2019). A new wave of innovation in Semantic web tools for drug discovery. *Expert Opinion on Drug Discovery, 14*(5), 433-444.

Gomathy, V., Padhy, N., Samanta, D., Sivaram, M., Jain, V., & Amiri, I. S. (2020). Malicious node detection using heterogeneous cluster based secure routing protocol (HCBS) in wireless adhoc sensor networks. *Journal of Ambient Intelligence and Humanized Computing*, *11*(11), 4995–5001. doi:10.1007/s12652-020-01797-3

Guha, A., & Samanta, D. (2021). Hybrid Approach to Document Anomaly Detection: An Application to Facilitate RPA in Title Insurance. *Int. J. Autom. Comput.*, *18*(1), 55–72. doi:10.1007/s11633-020-1247-y

Guo, Q. L. (2020). Multi-Model Data Query Languages and Processing Paradigms. In *International Conference on Information & Knowledge Management* (pp. 3505-3506). ACM.

Herman, I. (2009, November 12). *W3C Semantic Web Frequently Asked Questions*. Retrieved 11 17, 2020, from W3C Semantic Web: https://www.w3.org/2001/sw/SW-FAQ#swgoals

Huss, N. (2020, October 12). *How Many Websites Are There Around The World?* Retrieved 11 15, 2020, from siteefy: https://siteefy.com/how-many-websites-are-there/

Khamparia, A., Singh, P.K., Rani, P., Samanta, D., Khanna, A., & Bhushan, B. (2020). An internet of health things-driven deep learning framework for detection and classification of skin cancer using transfer learning. *Trans Emerging Tel Tech*. .10.1002/ett.3963

Krishnamurthy, G. C. (2008). Key differences between Web 1.0 and Web 2.0. *First Monday*, *13*(6).

Maheswari, Geetha, Selva Kumar, Karuppiah, Samanta, & Park. (n.d.). PEVRM: Probabilistic Evolution based Version Recommendation Model for Mobile Applications. *IEEE Access*. 10.1109/ACCESS.2021.3053583

Nandini, D. (2014). *Semantic Web And Ontology-eBooks.* eBooks and textbooks from bookboon.com.

NLearning. (2020, March 16). *Web 3.0 Examples*. Retrieved from NKN.org: https://nkn.org/community/blog/web-3-0-examples/

Padmanabhan, D. 2020, May 27). *Semantic Web*. Retrieved 11 19, 2020, from Devopedia: https://devopedia.org/semantic-web

PubChem. (2014, January 30). *PubChemRDF is Launched*. Retrieved 11 21, 2020, from PubChem Blog: https://pubchemblog.ncbi.nlm.nih.gov/tag/semantic-web/

Rudman, R. (2015). Web 3.0: Governance, risks and safeguards. *Journal of Applied Business Research*, *31*(3), 1037–1056. doi:10.19030/jabr.v31i3.9241

Ruta, M. S. (2018). A Blockchain Infrastructure for the Semantic Web of Things. *SEBD*, 1-10.

Semantics, C. (2020, March 21). *RDFS Introduction*. Retrieved 11 22, 2020, from Cambridge Semantics: https://www.cambridgesemantics.com/blog/semantic-university/learn-owl-rdfs/

Shah, N. K. (2012). E-learning and semantic web. *International Journal of e-Education, e-Business, e-Management Learning*, *2*(2), 113.

Sivakumar, P., Nagaraju, R., Samanta, D., Sivaram, M., Hindia, M. N., & Amiri, I. S. (2020). A novel free space communication system using nonlinear InGaAsP microsystem resonators for enabling power-control toward smart cities. *Wireless Networks*, *26*(4), 2317–2328. doi:10.1007/s11276-019-02075-7

Technology. (2020, August 14). *2.5 quintillion bytes of data generated everyday – Top Data Science Trends 2020*. Retrieved 11 15, 2020, from SG Analytics: https://us.sganalytics.com/

Trending-topics. (2018, November 20). *What Is the Semantic Web?* Retrieved 11 19, 2020, from Simplea: https://simplea.com/Articles/what-is-the-semantic-web

Valk, J. d. (2019, November 18). *Duplicate content: Causes and solutions*. Retrieved 11 17, 2020, from Yoast: https://yoast.com/duplicate-content/#:~:text=Search%20engines%20like%20Google%20have,show%20in%20the%20search%20results

Debabrata Samanta is presently working as Assistant Professor, Department of Computer Science, CHRIST (Deemed to be University), Bangalore, India. He obtained his B.Sc. (Physics Honors), from Calcutta University, Kolkata, India. He obtained his MCA, from the Academy of Technology, under WBUT, West Bengal. He obtained his PhD in Computer Science and Engg. from National Institute of Technology, Durgapur, India, in the area of SAR Image Processing. His areas of interest are SAR Image Analysis, Video surveillance, Heuristic algorithm for image classification, Deep Learning Framework for Detection and Classification, Blockchain, Statistical Modelling, Wireless Adhoc Network, Natural Language Processing, V2I Communication. He is the owner of 17 Indian Patents. He has authored and coauthored over 134 research papers in international journal (SCI/SCIE/ESCI/Scopus) and conferences including IEEE, Springer, and Elsevier Conference proceedings. He has received "Scholastic Award" at 2nd International conference on Computer Science and IT application, CSIT-2011, Delhi, India. He has published 9 books, available for sale on Amazon and Flipkart.