Indian Journal of Data Communication and Networking (IJDCN)
ISSN: 2582-760X (Online), Volume-1 Issue-2, April 2021

A Comprehensive Study of IoT Enabled Smart Grid

Naveen Kumar, Gopal Singh

Abstract- Systems that are used for monitoring and controlling are known as supervisory control and data acquisition systems. Not the entire control permissions, but rather the supervisory level is the primary focus of this. Several different kinds of sensors are being utilized in order to collect data in real-time. What is the Internet of Things (IoT)? It is a three-dimensional connectivity that can be used for anything, at any time, in any location. The comparison between the SCADA system and the Internet of Things is carried out in this study. In addition, this section of the study focused on the benefits of the Internet of Things (IoT) and offered some suggestions for integrating the IoT with the SCADA system.

Keywords: Automation, IoT, Vulnerability, Data Acquisition, Smart Grid

I. INTRODUCTION

When people talk about "the grid," they are referring to the electric grid, which is a network of transmission lines, substations, transformers, and other components that transport electricity from the power plant to individual homes and businesses. When you turn on your light switch or turn on your computer, it is what you plug into the electrical socket. The current electric grid that we use was constructed in the 1890s, and it has been updated after each decade as technological advancements have been made [1]. Currently, it is made up of more than 9,200 electric generating units that have a capacity of more than one million megawatts and are connected to transmission lines that are more than 300,000 miles long. We are pushing the patchwork nature of the electric grid to its limits, even though it is widely regarded as an engineering wonder [2]. Supervisory Control and Data Acquisition is what has been abbreviated as SCADA.

In the 20th century, the idea of SCADA was first considered and implemented. In order to control and monitor equipment that was put in faraway areas, numerous industries required this capability. To operate their machinery, they would dispatch personnel to far-flung areas. During the time that the computer was first developed and utilized for industrial control. Within the utilities industry, supervisory control was initially very well received.

Manuscript received on 01 March 2021 | Revised Manuscript received on 13 April 2021 | Manuscript Accepted on 15 April 2021 | Manuscript published on 30 December 2023.

**Correspondence Author(s)*
Naveen Kumar*, Research Scholar, Department of Computer Science & Applications, M.D. University, Rohtak (Haryana), India. E-mail: er.naveendahiya@gmail.com, ORCID ID: 0000-0002-6773-8048
Dr. Gopal Singh, Assistant Professor, Department of Computer Science & Applications, M.D. University, Rohtak, (Haryana), India. E-mail: gsbhoria@gmail.com, ORCID ID: 0000-0001-8282-4959

A. Testing the Smart Grid

There will be millions of components and parts that make up the Smart Grid. These include controls, computers, power lines, and various new technologies and pieces of equipment. Once all of the technologies have been perfected, the equipment that has been installed, and the systems that have been tested, it will take some time before they can be used. And it won't happen all at once; the Smart Grid is going to evolve piece by piece over the course of the next decade or two. The Internet has already brought about a transition in the way that people live, work, play, and learn. It is conceivable that the Smart Grid will bring about the same kind of change once it reaches its maturity.

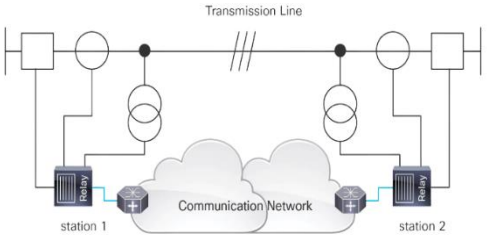

Figure 1: Communication Network [4]

II. RELATED WORK

The comparison between SCADA and the Internet of Things is taken into consideration when studying a variety of research papers and articles. Here is a list of some of those on the list:

A comparative investigation has been performed, and the communication protocols of both of these entities have been described. In addition, they brought attention to the risks that SCADA and IoT.

The need for dynamic control and power management is emphasized three times. In addition to this, they attempt to elucidate the shortcomings of the current system. In addition to this, they brought up the execution of programming, testing, and the adjustment of the output state of the system.

III. SCADA SYSTEM

In the 1970s, the acronym SCADA did not make its debut until much later. PLCs, which stand for programmable logic controllers, and RTUs, which stand for remote terminal units, were used to initiate the SCADA system. Both PLCs and RTUs are examples of microcomputers that are capable of communicating with multiple objects of the same type simultaneously. This system is capable of controlling and monitoring operations, as well as creating a log file that contains a record of all events.

Sensors [22,24,27], motors, valves, and other controls are included in SCADA. In industrial organizations, it is utilized to a great extent. When it comes to making intelligent decisions, it helps to boost efficiency and process data. Some examples of public-sector undertakings (PSUs) that make use of this system include those in energy, oil and gas, transportation, manufacturing, and other sectors. SCADA is not a specific technology; rather, it is a form of application or pure software package that facilitates interaction between hardware and programmable logic controllers (PLCs).

A. Data Acquisition System

The process of retrieving information from pieces of equipment that are not always in the order that was intended is known as data acquisition. To put it another way, data acquisition is the process of utilizing a computer to measure a physical quantity or an electrical quantity, such as temperature, current, voltage, sound, and so on. The computer requires additional hardware and sensors in order to measure such a quantity. Data measurement, data transformation, and data processing are all performed by a computer that is equipped with software. This computer is also used to control the various activities [3],[4],[5],[6],[7].

There are many different kinds of application software that provide facilities such as analyzing, obtaining, and measuring the parameters of data. SCADA offers a facility that allows for the collection of data from a variety of sensors and the transmission of that data back to the control action.

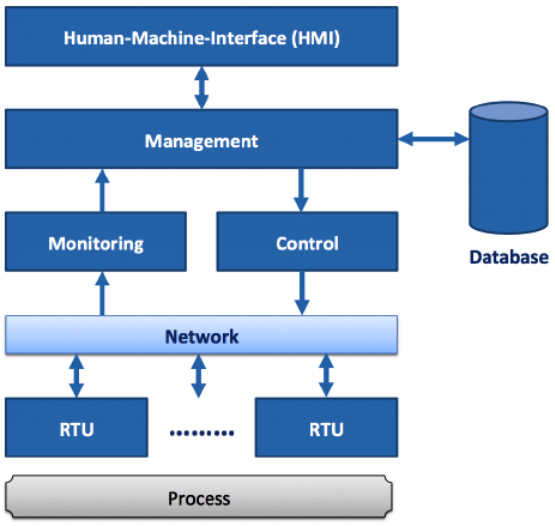

Figure: 2 Architecture of SCADA [5]

Some common sensors are enlisted below:

Table: 1 Common Sensors used by SCADA

Sr. No	Measure Quantity	Sensors
1.	Force and Pressure	Strain Gage, Piezoelectric Transducer
2.	Position and Displacement	Potentiometer, LVDT, Optical Encoder
3.	Temperature/heat	Thermocouple, RTD, Thermistor
4.	Light	Photo Sensor
5.	Sound/Voice	Microphone
6.	pH	pH Electrode

B. Control Mechanism of SCADA

By utilizing switches, the SCADA system is able to exercise control over the devices. Although it is controlled automatically, there are certain circumstances in which it must be handled manually or by a human. What is known as the Human-Machine Interface (HMI) is provided by the SCADA. Human-machine interfaces (HMI) display the information that a human has requested [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [42],[43],[44],

IV. INTERNET OF THINGS

The IoT is a collection of various objects/things/modern technologies and working together in the form of a network of devices. The IoT is next industrial revolution which are also known as industry 4.0 [18], [19], [20], [21].

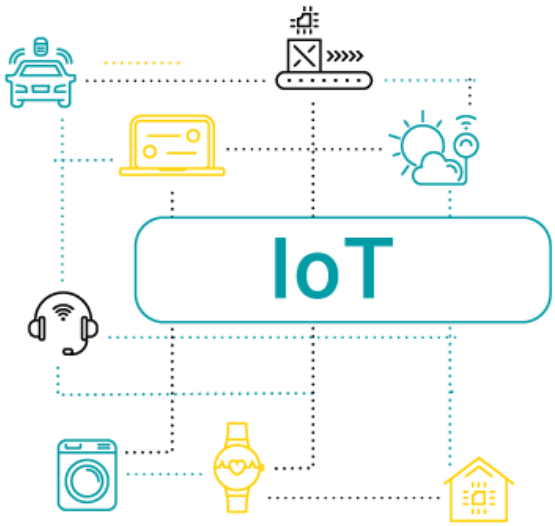

Figure 3: IoT Connectivity [6]

The IoT have also various type of sensors contain the sensing elements. And these sensors are sensing the quantity and send them to requested node [22]. [23], [24], [25], [26]. Sensors and their measuring quantity

Table: 2 Common Sensors used by IoT

Sr. No	Sensors	Description
1.	Proximity	Presence of object
2.	Infrared	Detect infrared radiation.
3.	Gyroscope	Angular velocity or angular rate.
4.	Optical	Measure physical quantity of light rays.
5.	Accelerometer	Measurable acceleration

V. COMPARISON ANALYSIS

Table 3: Comparative Analysis of IoT Parameters

Sr. No.	Features	IoT	Existing Technology
1.	Scalability	Have the capacity to process any quantity of data	Traditional architecture, a restricted user base, and slower report execution times [27], [28], [29]
2.	Data Analysis	In addition to being backed by a machine learning module, long-term data.	It is a smaller amount of data, and there is no historical data [30]

3.	Standardization	OPC-UA is used for collect data.	For Data gathering OPC is used [31], [32].
4.	Interoperability	MQTT protocol as a means of enabling communication between different devices.	There is no support for devices that come from a different manufacturer or that use a different version of software [33].

The SCADA and Internet of Things are components that are required for sensors to communicate with real-time equipment to acquire data [34], [35], [36]. A network of physical devices that are connected to one another by electrical means, software configuration, sensors, and network connectivity is referred to as the internet of Things (IoT). Each platform has several advantages, but it also has some advantages and certain vulnerabilities. When it comes to communication, the Internet of Things communicates with one another through the Internet and with other devices. For communication, the protocols MQTT, XMPP, DDS, and AMQP are utilized. During the process of collecting devices and communicating with the server, the MQTT protocol is utilized. SCADA have many vulnerabilities i.e slow updates, lack of knowledge of devices etc [37], [38], [39], [40], [41].

VI. CONCLUSION AND FUTURE SCOPE

The Supervisory Control and Data Acquisition system as well as the Internet of Things are also topics that are covered in the study. During this investigation, the common sensors that are utilized by SCADA and IoT are also being identified. The Internet of Things makes use of a large number of sensors; however, this study only focuses on a few of the most common sensors. IoT is significantly more efficient than SCADA. Additionally, the communication protocol that the Internet of Things uses should be discussed. Currently, the Smart Grid is at its infant stage of development. The entire power community is currently engaged in the process of comprehending and constructing intelligent power grid systems, which is a topic that will be required in the future. To expose the weaknesses of SCADA, overcome those weaknesses, and integrate with the Internet of Things, this paper has been prepared. The industry is likely to undergo the next revolution, which is known as Industry 4.0 if the existing technology is combined with the Internet of Things.

DECLARATION STATEMENT

Funding	No, I did not receive.
Conflicts of Interest	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material	Not relevant
Authors Contributions	All authors have equal participation in this article.

REFERENCES

1. Data Acquision, last accessed on 15 june 2019, http://www.ni.com/data-acquisition/what-is/
2. R. Dhobley and A. Chopde, “Comparative Analysis of Traditional SCADA Systems and IoT Implemented SCADA”, International Journal of Advance Research, Ideas and Innovations in Technology, volume 3, issue 6, 2017.
3. R. Bhaiswar et al , “Power Management using PLC and SCADA”, International Journal of Engineering Innovation & Research Volume 1, Issue 1, ISSN : 2277 – 5668,2012.
4. Last Accessed on 12 july 2021 link: https://www.softwebsolutions.com/resources/scada-system-vs-iot.html
5. Last Accessed on 10 july 2021 link: https://www.softwebsolutions.com/resources/scada-system-vs-iot.html
6. Last Accessed on 11 july 2021 link: https://www.iotnxt.com/2018/07/18/iot-or-scada/
7. Last Accessed on 11 july 2021 link: https://www.finoit.com/blog/sensor-types-used-iot/
8. ASHRAE, “Ventilation for acceptable indoor air quality,” Amer. Soc. Heating, Refrigerating Air-Conditioning Eng. Inc, Atlanta, GA, USA, Standard 62.1-2004, 2004.
9. S. Paudyal, C. A. Cañizares, and K. Bhattacharya, “Three-phase distribution OPF in smart grids: Optimality versus computational burden,” in Proc. Innov. Smart Grid Technol. Europe, Manchester, U.K., Dec. 2011, pp. 1–7. https://doi.org/10.1109/ISGTEurope.2011.6162628
10. S. H. Low, “Convex relaxation of optimal powr flow—Part I: Formulations and equivalence,” IEEE Trans. Control Netw. Syst., vol. 1, no. 1, pp. 15–27, Mar. 2014. https://doi.org/10.1109/TCNS.2014.2309732
11. T. Kuruganti and M. Brambley, “Building-to-grid technical opportunity: From the information and communications technology perspective,” DOE Energy Efficiency & Renew. Energy, Washington, DC, USA, Tech. Rep. DOE/EE-1054, Feb. 2016.
12. Ameren. Power Smart Pricing; A Smart Electricity Rate from Ameren Illinois. Accessed on Jun. 3, 2015. [Online]. Available: https://www.powersmartpricing.org/
13. The COMED Residential Real-Time Pricing Program Guide, Commonwealth Edison (ComEd), Chicago, IL, USA. Accessed on Jun. 3, 2015. [Online]. Available: https://www.comed.com/documents/customer-service/ rates-pricing/real-time-pricing/rrtpprogramguide.pdf
14. Z. Wang, “Compensation methods for demand response,” M.S. thesis, Dept. Elect. Comput. Eng., Univ. Kentucky, Lexington, KY, USA, 2015.
15. N. Kumar and G. Singh, “A Novel Algorithm to Improve the Power Quality for the Smart Grid and Integration with the Optimization Framework”. International Journal of Engineering Trends and Technology, 69(9),272-280. DOI: https://ijettjournal.org/archive/ijett-v69i9p233 https://doi.org/10.14445/22315381/IJETT-V69I9P233
16. Kumar, N., & Singh, G. (2019). Energy Efficient Load Optimization Techniques for Smart Grid with Futuristic Ideas. International Journal of Engineering and Advanced Technology, 9(1), 4327–4331. https://doi.org/10.35940/ijeat.a1778.109119.
17. Kumar, N., & Singh, G. (2020). [PDF] Load Optimization Framework for Smart Grid: A Systematic Review | Semantic Scholar. http://Www.Ijcstjournal.Org/Volume-8/Issue-5/IJCSTV8I5P7.Pdf
18. Singh, G., Rohil, H., Rishi, R., & Ranga, V. (2019). LETSRP: A Secure Routing Protocol for Manets. International Journal of Engineering and Advanced Technology, 9(1),498–504. https://doi.org/10.35940/ijeat.a9630.109119.
19. Singh, R., & Gill, N. S. (2020). View of Use of IoT and Machine Learning for Efficient Power Management Through Smart Grid: A Review. IJAST. http://sersc.org/journals/index.php/IJAST/article/view/30681/17037.
20. S. Mohagheghi and N. Raji, "Managing industrial energy intelligently: Demand response scheme," IEEE Industry Applications Magazine, vol. 20, pp. 53-62, 2014. https://doi.org/10.1109/MIAS.2013.2288387
21. A. Brooks, E. Lu, D. Reicher, C. Spirakis, and B. Weihl, "Demand dispatch," IEEE Power and Energy Magazine, vol. 8, pp. 20-29, 2010. https://doi.org/10.1109/MPE.2010.936349
22. Y. M. Ding, S. H. Hong, and X. H. Li, "A demand response energy management scheme for industrial facilities in smart grid," IEEE Transactions on Industrial Informatics, vol. 10, pp. 2257-2269, 2014. https://doi.org/10.1109/TII.2014.2330995

23. HATTAM, L., & GREETHAM, D. V. (2016). Green neighbourhoods in low voltage networks: measuring impact of electric vehicles and photovoltaics on load profiles. Journal of Modern Power Systems and Clean Energy, 5(1), 105–116. https://doi.org/10.1007/s40565-016-0253-0.
24. Poghosyan A, Greetham DV, Haben S et al (2015) Long term individual load forecast under different electrical vehicles uptake scenarios. Appl Energy 157:699–709. https://doi.org/10.1016/j.apenergy.2015.02.069
25. Building Energy Data Book. [Online]. Available: http://buildingsdatabook.eren.doe.gov.in (Dec. 10, 2014).
26. M. Maasoumy, M. Razmara, M. Shahbakhti, and A. S. Vincentelli, "Handling model uncertainty in model predictive control for energy efficient buildings," J. Energy Build., vol. 77, pp. 377–392, Jul. 2014. https://doi.org/10.1016/j.enbuild.2014.03.057
27. S. Privara et al., "Building modeling as a crucial part for building predictive control," J. Energy Build., vol. 56, pp. 8–22, Jan. 2013. https://doi.org/10.1016/j.enbuild.2012.10.024
28. J. Ma, S. J. Qin, B. Li, and T. Salsbury, "Economic model predictive control for building energy systems," in Proc. IEEE PES Innov. Smart Grid Technol., 2011, pp. 1–6.
29. M. Pcolka, E. Žá ˇ ceková, R. Robinett, S. ˇ Celikovský, and M. Šebek, ˇ "Economical nonlinear model predictive control for building climate control," in Proc. Amer. Control Conf. (ACC), Portland, OR, USA, 2014, pp. 418–423. https://doi.org/10.1109/ACC.2014.6858928
30. A. Brooks, E. Lu, D. Reicher, C. Spirakis, and B. Weihl, "Demand dispatch," IEEE Power Energy Mag., vol. 8, no. 3, pp. 20–29, May/Jun. 2010. https://doi.org/10.1109/MPE.2010.936349
31. M. C. Bozchalui, S. A. Hashmi, H. Hassen, C. A. Cañizares, and K. Bhattacharya, "Optimal operation of residential energy hubs in smart grids," IEEE Trans. Smart Grid, vol. 3, no. 4, pp. 1755–1766, Dec. 2012. https://doi.org/10.1109/TSG.2012.2212032
32. S. Shao, M. Pipattanasomporn, and S. Rahman, "Demand response as a load shaping tool in an intelligent grid with electric vehicles," IEEE Trans. Smart Grid, vol. 2, no. 4, pp. 624–631, Dec. 2011. https://doi.org/10.1109/TSG.2011.2164583
33. Kumar, N., & Singh, G. (2022). A study of ATC losses, tools, techniques and ongoing applications in smart grid. *International Journal of Engineering Trends and Technology*, *70*(3), 140-150. https://doi.org/10.14445/22315381/IJETT-V70I3P216
34. Kumar, N., Singh, G., & Kebede, H. (2023). An Optimized Framework of the Integrated Renewable Energy and Power Quality Model for the Smart Grid. *International Transactions on Electrical Energy Systems, 2023*. https://doi.org/10.1155/2023/6769690
35. J. Taylor, A. Maitra, M. Alexander, D.Brooks, and M. Duvall, "Evaluations of plug-in electric vehicle distribution system impacts," in Proc. IEEE Power Energy Soc. Gen. Meeting, Minneapolis, MN, USA, 2010, pp. 1–6. https://doi.org/10.1109/PES.2010.5589538
36. 34. B. Jin, P. Nuzzo, M. Maasoumy, Y. Zhou, and A. Sangiovanni-Vincentelli, "A contract-based framework for integrated demand response management in smart grids," in Proc. 2nd ACM Int. Conf. Embedded Syst. Energy Efficient Built Environ., Seoul, South Korea, 2015, pp. 167–176.
37. J. Hagerman, G. Hernandez, A. Nicholls, and N. Foster, "Buildings-togrid technical opportunities: Introduction and vision," U.S. Dept. Energy, Energy Efficient and Renewable Energy (EERE), Washington, DC, USA, Tech. Rep., 2014. https://doi.org/10.2172/1220813
38. Kumar, N., & Singh, G. K. (2022). The Performance Analysis of Optimized Integrated Framework for Smart Grid. *Indian Journal of Signal Processing (IJSP)*, *2*(3), 1–4. https://doi.org/10.54105/ijsp.d1010.082322
39. S. Bera, S. Misra, and J. P. C. Rodrigues, "Cloud computing applications for smart grid: A survey," IEEE Trans. Parallel Distrib. Syst., vol. 26, no. 5, pp. 1477–1494, May 2015. https://doi.org/10.1109/TPDS.2014.2321378
40. J. Haack, B. Akyol, B. Carpenter, C. Tews, and L. Foglesong, "Volttron: An agent platform for the smart grid," in Proc. Int. Conf. Auton. Agents Multi-Agent Syst., St. Paul, MN, USA, May 2013, pp. 1367–1368.
41. W. Khamphanchai et al., "Conceptual architecture of building energy management open source software (BEMOSS)," in Proc. Innov. Smart Grid Technol. Conf. Europe, Istanbul, Turkey, 2014, pp. 1–6. https://doi.org/10.1109/ISGTEurope.2014.7028784
42. Priyanka, R., & Reji, M. (2019). IOT Based Health Monitoring System Using Blynk App. In International Journal of Engineering and Advanced Technology (Vol. 8, Issue 6, pp. 78–81). https://doi.org/10.35940/ijeat.e7467.088619
43. P, B., & Geetha D, D. M. (2019). Design and Experimentation of Face liveliness Detection using Temperature Gradient and Image Quality Assessment. In International Journal of Recent Technology and Engineering (IJRTE) (Vol. 8, Issue 3, pp. 4360–4362). https://doi.org/10.35940/ijrte.c5516.098319
44. Thakur, T. B., & Mittal, A. K. (2020). Real Time IoT Application for Classification of Crop Diseases using Machine Learning in Cloud Environment. In International Journal of Innovative Science and Modern Engineering (Vol. 6, Issue 4, pp. 1–4). https://doi.org/10.35940/ijisme.d1186.016420

AUTHORS PROFILE

Naveen Kumar is currently pursuing Ph.D. from M. D University, Rohtak. He has awarded Master Degree in Computer Science from Maharshi Dayanand University, Rohtak, and Haryana, India. He has published/presented more than 5 research papers in national journals/conferences. His research interests include Internet of Things, Power Systems, Adhoc Networks.

Dr. Gopal Singh started his career as Lecturer at Dept. of Computer Sc. & Applications, Ch. Devi Lal University, Sirsa (Haryana) in 2007. He is working as Assistant Professor at Dept. of Computer Sc. & Applications, Maharshi Dayanand University, Rohtak (Haryana) since 2009. He obtained his M.Tech. (CSE) from Kurukshetra University, Kurukshetra in 2004 and MCA from Guru Jambheshwar University of Sc. & Technology, Hisar in 2002. He obtained his Ph. D. from Department of Computer Sc. & Engineering, UIET, Maharshi Dayanand University, Rohtak (Haryana) in the field of wireless communication i.e., Mobile Ad Hoc Network. His research interests include wireless communication, Internet of Things (IoT), Cloud Computing etc. He has published around 30 research papers in peer reviewed journals and conferences.