International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 2 Volume No.7 March - April – 2023
DOI:10.46647/ijetms.2023.v07i02.057 ISSN: 2581-4621

ONE PASS PACKET STEERING IN SOFTWARE DEFINED DATA CENTERS

R.Sudhakar[1], V.Ramkumar[2], S.Santhosh[3], J.Suganth[4], D.Thirunavukkarasu[5]
[1]Assistant Professor – Computer Science and Engineering, Nandha College of Technology, Erode, Tamil Nadu
[2,3,4,5]UG – Computer Science and Engineering, Nandha College of Technology, Erode, Tamil Nadu
Corresponding Author Orcid ID : https://orcid.org/0009-0008-1705-9128

ABSTRACT
Issue of service function chaining in a network is the focus of this paper. Currently, middle box placement in a network and packet steering through middle boxes are the two main problems associated with chaining services in a network—also known as service function chaining. We propose a One Pass Packet Steering (OPPS) method for use in multi-subscriber environments with the goal of reducing the total amount of time it takes for Users and Services to connect. We show a proof of idea execution utilizing imitations performed with Mininet. According to our findings, the end-to-end delay of subscribers utilizing different sets of policy chains with the same middle boxes and a fixed topology remains roughly the same. Software-Defined Networking, or SDN for short, is a new way of networking that gives a controller and its applications the all-powerful ability to see the whole network and program it in any way they want. This makes it possible for new innovations in network protocols and applications. SDN's logically centralized control plane, which gives visibility to the entire network and is used by many SDN applications, is one of its main benefits. We propose new SDN-specific attack vectors that seriously challenge this foundation, a first in the literature. While the spirit of our new attacks is somewhat similar to that of spoofing attacks in legacy networks, such as the ARP poisoning attack, there are significant differences in how unique vulnerabilities are exploited and how current SDN differs from legacy networks.
Keywords: SDN; Packet steering; Middlebox; Policy chain; One Pass Packet Steering (OPPS); Data Center; Control plane; Data plane; Tenant; SDN performance.

1. INTRODUCTION

1.1 SOFTWARE DEFINED NETWORKS

By separating the control plane from the data plane (e.g., switches), Software-Defined Networking (SDN) has emerged as a new network paradigm to innovate the ossified network infrastructure, providing holistic network visibility and flexible programmability. A SDN controller, the network's brain, gives users a great design and control tool. The project is shared equally by the first two authors. the controller's core services by employing their own applications on top of the network. SDN, particularly its well-known implementation OpenFlow1, has been increasingly utilized not only in academic settings but also in real-world production networks. Since then, numerous application scenarios, including campus network innovation, cloud network virtualization, and data center network optimization, have been studied and implemented. Since the controller is the heart of the SDN architecture, if the Open Flow controller has a serious design or implementation flaw, the entire network would be in chaos or even completely under the control of the attackers.

1.2 ONE PASS PACKET STEERING

By quickly directing packets to their intended destinations without having to examine them multiple times, one pass packet steering improves performance and reduces latency in network packet processing. Traditionally, the classification, filtering, and forwarding of packets are just a few of the stages that make up packet processing. The inspection and processing of the packet at each stage can lead to an increase in latency and a decrease in performance. With one pass parcel guiding, bundles are ordered and separated once and afterward coordinated to their planned objections minus any

DOI:10.46647/ijetms.2023.v07i02.057 ISSN: 2581-4621

additional handling. Using cutting-edge packet processing hardware and software that can carry out these operations in real time makes this method feasible. One-pass packet steering can boost throughput, reduce latency, and improve network performance by reducing the number of times a packet is inspected and processed. This can be especially useful in high-speed network environments like data centers, where delivering services and applications requires low latency and high throughput. Overall, modern networking software and hardware frequently employ one pass packet steering, which is a crucial method for reducing latency and improving network performance.

1.3 SHORTEST PATH ON SDN ENVIRONMENT

The gap between Internet service provider (ISP) costs and revenues is widening as residential broadband consumption rises rapidly. In the interim, expansion of Web empowered gadgets is blocking access organizations, corrupting end-client experience, and influencing content supplier adaptation. Using open APIs supported by software defined networking (SDN), we propose a new model in which the content provider explicitly signals to the ISP on a per-flow basis the requirements for the fast and slow lane. Our first contribution is the creation of an architecture to support this model and the presentation of arguments demonstrating how this is advantageous to content providers (fine-grained control over peering arrangement), ISPs (two-sided revenue), and consumers (better user experience). Our second contribution is to evaluate our proposal using a real trace of more than ten million flows. This demonstrates that the use of dynamic fast lanes can almost completely eliminate degradation in video flow quality and that the use of slow lanes for bulk transfers can greatly improve load times on websites. Our third contribution is to create a fully operational prototype of our system by utilizing instrumented video/file transfer servers, open-source SDN components (Open flow switches and POX controller modules), to demonstrate the approach's viability and performance advantages. Open and agile access network service quality management that is acceptable to users, ISPs, and content providers is the long-term objective of our proposal, which is a first step in that direction.

2. LITERATURE REVIEW

2.1 TRICKLE: A SELF-REGULATING ALGORITHM FOR CODE PROPAGATION AND MAINTENANCE IN WIRELESS SENSOR NETWORKS

Trickle, an algorithm for distributing and maintaining code updates in wireless sensor networks, is what we present here. Trickle employs a "polite gossip" policy, employing methods from the epidemic/gossip, scalable multicast, and wireless broadcast literature. This means that motes periodically broadcast a code summary to their neighbors but remain silent if they have recently heard a summary that is identical to theirs. A mote broadcasts an update whenever it hears a summary that is older than its own. The algorithm regulates the send rate so that each mote only receives a trickle of packets, just enough to stay current, rather than flooding a network with packets. Trickle can propagate new code in a matter of seconds, scale to thousand-fold changes in network density, and impose a maintenance cost of a few sends per hour, as demonstrated by our demonstration of this straightforward mechanism.

2.2 DATA DISCOVERY AND DISSEMINATION WITH DIP

We present DIP, a wireless network data discovery and dissemination protocol. Overheads in previous methods, like Trickle and SPIN, scale linearly with the number of data items. DIP can use O(log(T)) packets to identify new items for T items while maintaining an O(1) detection latency. DIP employs a hybrid strategy of randomized scanning and tree-based directed searches in order to achieve this performance across a broad range of network configurations. DIP outperforms both in terms of transmission speed and performance by dynamically selecting which of the two algorithms to use. DIP sends 20-60% fewer packets than existing protocols and can be 200% faster, all while requiring only O(log(log(T)) of additional state per data item, according to simulation and testbed experiments.

2.3 TINYECC: A CONFIGURABLE LIBRARY FOR ELLIPTIC CURVE CRYPTOGRAPHY IN WIRELESS SENSOR NETWORKS

In traditional networks like the Internet, Public Key Cryptography (PKC) has served as the enabling technology for numerous security services and protocols. One of the most effective types of PKC, elliptic curve cryptography (ECC), is being studied for use in wireless sensor networks to support PKC in sensor network applications and enable the utilization of existing PKC-based solutions. TinyECC, a configurable library for ECC operations in wireless sensor networks, is the subject of this paper's design, implementation, and evaluation. TinyECC's primary goal is to offer a ready-to-use, publicly accessible software package for ECC-based PKC operations that can be easily configured and incorporated into sensor network applications. TinyECC provides a number of optimization switches that developers can use to turn on or off particular optimizations. TinyECC developers have a lot of leeway when it comes to integrating it into sensor network applications because different combinations of the optimizations have different execution times and resource consumptions. The experimental evaluation of TinyECC on several common sensor platforms, including MICAz, Tmote Sky, and Imote2, is also reported in this paper.]

2.4 DHV: A CODE CONSISTENCY MAINTENANCE PROTOCOL FOR MULTI-HOP WIRELESS SENSOR NETWORKS

In dynamic, unreliable multi-hop sensor networks, it is challenging to ensure that each sensor node has the same code version. The network may not function as intended when nodes have different code versions, resulting in time and effort wastage. We propose and evaluate DHV, a practical protocol for maintaining code consistency so that every network node will eventually have the same code. The straightforward observation that two code versions frequently differ only by a small number of the least significant b its of their binary representation is the foundation of DHV. To detect a more recent code version in the network, DHV enables nodes to carefully select and transmit only the necessary bit level information. Version differences in O(1) messages and latency in relation to the logarithmic scale of current protocols are both detectable by DHV.

2.5 EFFICIENT AND SECURE SOURCE AUTHENTICATION FOR MULTICAST

Source authentication, which enables recipients of multicast data to verify that the received data originated with the claimed source and was not altered in transit, is one of the main challenges in securing multicast communication. In common situations where lost packets are not retransmitted and other data receivers are not trusted, the issue becomes more complex. For multicast, a number of source authentication methods have been proposed, but none of them are effective enough in all important parameters. TESLA, a highly effective method that relies on the sender's delayed release of keys after initial loose time synchronization, was recently proposed by us. TESLA is the subject of several substantial changes and enhancements proposed in this paper. In contrast to TESLA, which requires buffering packets on the receiver side and only provides delayed authentication, one modification enables receivers to authenticate the majority of packets as soon as they arrive.

3. EXPERIMENTAL METHODS OR METHODOLOGY

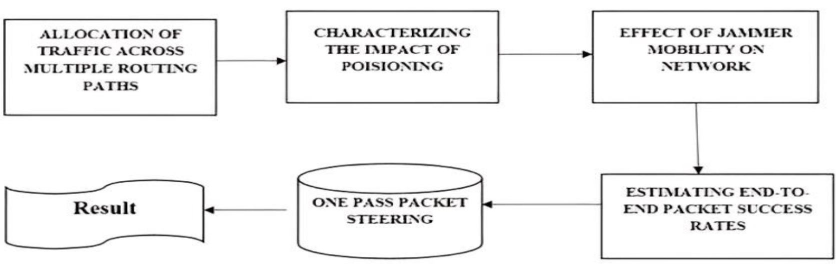

Fig 1. Allocation of Traffic Across Multiple Routing Paths

International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 2 Volume No.7 March - April – 2023
DOI:10.46647/ijetms.2023.v07i02.057 ISSN: 2581-4621

4. EXISTING SYSTEM

Source authentication, which enables recipients of multicast data to verify that the received data originated with the claimed source and was not altered in transit, is one of the main challenges in securing multicast communication. In common situations where lost packets are not retransmitted and other data receivers are not trusted, the issue becomes more complex. For multicast, a number of source authentication methods have been proposed, but none of them are effective enough in all important parameters. TESLA, a highly effective method that relies on the sender's delayed release of keys after initial loose time synchronization, was recently proposed by us. TESLA is the subject of several substantial changes and enhancements proposed in this paper. In contrast to TESLA, which requires buffering packets on the receiver side and only provides delayed authentication, one modification enables receivers to authenticate the majority of packets as soon as they arrive.

5. PROPOSED SYSTEM

In the work we propose, we call for modifying middleboxes so that the OPPS module takes over the implementation of particular middlebox actions based on the middlebox category. We assume that our middlebox island does not experience packet fragmentation in order to simplify the objectives. A cluster of only middleboxes in a network is referred to as a middlebox island by us. Middleboxes are also assumed to be aware of the newly added fields. modules that make up OPPS. The system's core modules are discussed in the following sections. We investigate potential defense strategies for TopoGuard (Topology Guard) in order to mitigate such attacks. We note that it is difficult to simply use static configuration to solve the issue—similar to using a static ARP entry for hosts or the port security feature for switches to combat ARP poisoning attacks—because this method necessitates time-consuming and error-prone manual labor and is not suitable for managing network dynamics—a valuable SDN innovation. In this project, we propose TopoGuard, a new security extension to the existing VM OpenFlow controllers that provides automatic and real-time detection of Virtual Machine exploitation to better balance security and usability. TopoGuard prevents the Host Location Hijacking Attack and the Link Fabrication Attack by utilizing SDN-specific features to check the legitimacy of host migration and switch port property.

5.1 ALLOCATION OF TRAFFIC ACROSS MULTIPLE ROUTING PATHS

In the case of a lossy network flow optimization problem, this module is used to distribute traffic across multiple routing paths. Using portfolio selection theory, we convert the optimization problem into the asset allocation problem by allowing individual network nodes to locally characterize the impact of the incident and aggregate this data for the source nodes. On the SDN/OpenFlow Topology Management Service, we carry out the initial security assessment. In particular, we have found new vulnerabilities in eight mainstream. SDN/VM OpenFlow controllers' Device Tracking Service and Link Discovery Service.

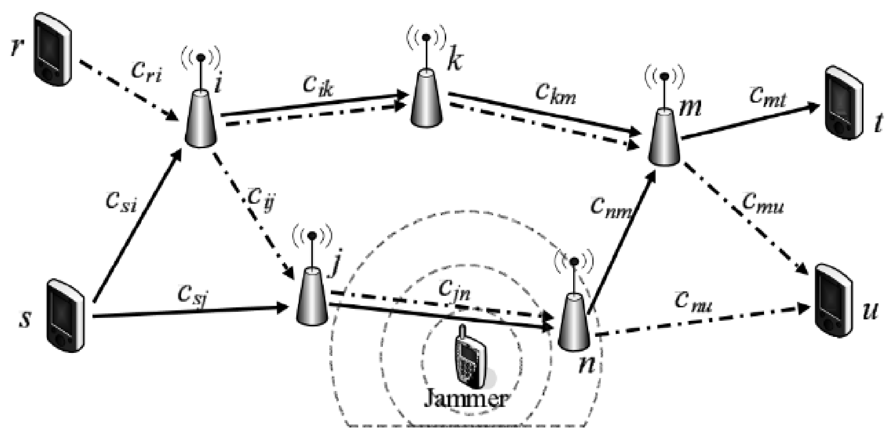

Fig 2. Allocation of Traffic Across Multiple Routing Paths

DOI:10.46647/ijetms.2023.v07i02.057 ISSN: 2581-4621

5.2 CHARACTERIZING THE IMPACT OF POISIONING

The network nodes in this module estimate and describe the impact of position, and a source node uses these estimates to allocate traffic. It is necessary to estimate the impact of poision on transmissions over each link in order for a source node to incorporate the impact of poision into the traffic allocation problem. However, the local estimates must be continuously updated in order to capture the jammer's mobility and the dynamic effects of the poison attack. To take advantage of the flaws we've discovered, we propose Virtual Machine Poisoning Attacks. In both a hardware SDN testbed and the Netbeans emulation environment, we demonstrate the viability of those attacks.

5.3 EFFECT OF JAMMER MOBILITY ON NETWORK

In This module, the capacity indicates the maximum number of items that can be transferred over the wireless link using min/max scheduling. When the source is producing data at a high packet delivery rate, it should be transmitted at the appropriate time for interference to occur. Then, at that point, the throughput rate to be less. The traffic allocation can be altered if the source node becomes aware of this effect, resulting in a low delivery ratio on each path and restoring the damage path.

5.4 EVALUATING END-TO-END SUCCESS RATES FOR PACKAGES

In order to determine the most effective traffic allocation, the source must estimate the effective end-to-end packet success rate for the links in a routing path. assuming that the total amount of time it takes to transport packets from each source to the appropriate destination is minimal in comparison to the update relay period. TopoGuard, a prototype defense system that is currently implemented in Floodlight but could be easily extended to other controllers, is part of our investigation into the defense space and includes automatic mitigation strategies for Virtual Machine Poisoning Attacks. Our assessment shows that TopoGuard forces just an irrelevant execution above

6. EXPERIMENTAL SETUP

The functions of the owner, user, and sensor node of the network are carried out by programs. to use the data hash chain method to put Topogaurd SDN into action.

The user-side program of Topogaurd now has the following new features: the creation of the signature packet and all data packets, the data hash chain for a round of dissemination data, and based on Topogaurd SDN's design.

Based on the verify function and the Link Fabrication attack hash function, we implement the verification function for data and signature packets. Also, in our experiment, when a laptop computer disseminates data, it first sends it to a repeater, which is a specific sensor node in the network, via the serial port. The repeater then uses Topogaurd SDN to carry out the dissemination on the user's behalf.

Table 6.1: Running Time for each phase of the basic protocol of Topogaurd SDN

	System Initialization	IP-Link Attacks	Fabrication	The certificate generation (i.e., signing a 20 byte message)
Time (CPU = 1.8 GHz) (µs)	1608.0	1576.31		634.8
Time (CPU = 2.6 GHz (µs)	1111.3	1092.12		435.4
Time (CPU = 3.1 GHz) (µs)	931.1	915.18		372.3

(Except the Sensor node verification phase)

7. CONCLUSION

The Poisoning Network routing has been developed in such a structured manner which is reducing the traffic further development. The coding is done in simplified manner as they are more understandable and flexible. The evaluate the effect of varying network and protocol parameters in order to observe the performance trends using the poison -aware traffic allocation formulation. In particular, we are interested in the effect of the update relay period and the maximum number of routing paths on the performance of the flow allocation. In order to compare trials with different update times or numbers of paths, we average the simulated results over each simulation run, yielding a single. We simulate a small-scale network similar to that in while varying network and protocol parameters in order to observe performance trends are made for further developments.

8. REFERENCES

1. Y. Yiakoumis et al., "Putting home users in charge of their network," in Proc. ACM UbiComp, Sep. 2012, pp. 1114–1119.

2. Y. Yiakoumis, K. Yap, S. Katti, G. Parulkar, and N. McKeown, "Slicing home networks," in Proc. SIGCOMM HomeNets Workshop, Aug. 2011, pp. 1–6.

3. J. Matias, E. Jacob, N. Katti, and J. Astorga, "Towards neutrality in access networks: A NANDO deployment with OpenFlow," in Proc. Int. Conf. Access Netw., Jun. 2011, pp. 7–12.

4. A.Kumar et al., "BwE: Flexible, hierarchical bandwidth allocation for WAN distributed computing," in Proc. ACM SIGCOMM, Aug. 2015, pp. 1–14.

5. C.Joe-Wong, S. Ha, and M. Chiang, "Time-dependent broadband pricing: Feasibility and benefits," in Proc. IEEE ICDCS, Jun. 2011, pp. 288–298.

6. P. Danphitsanuphan, "Dynamic bandwidth shaping algorithm for Internet traffic sharing environments," in Proc. World Congr. Eng., Jul. 2011, pp. 1–4.

7. NikolaosLaoutaris, Michael Sirivianos, Xiaoyuan Yang, and Pablo Rodriguez "Inter-Datacenter Bulk Transfers with NetStitcher"Telefonica Research Barcelona, Spain nikos@tid.es, irivi@tid.es, yxiao@tid.s, pablorr@tid.es

8. A.Mahimkar et al., "Bandwidth on demand for inter-data center communication," in Proc. ACM HotNets Workshop, Nov. 2011, Art. no. 24.

9. R. K. P. Mok, E. W. W. Chan, and R. K. C. Chang, "Measuring the quality of experience of HTTP video streaming," in Proc. IFIP/IEEE Int. Symp. Integr. Netw. Manage., May 2011, pp. 485–492.

10. H. H. Gharakheili, A. Vishwanath, and V. Sivaraman, "Pricing usersanctioned dynamic fast-lanes driven by content providers," in Proc. IEEE INFOCOM Workshop Smart Data Pricing (SDP), Apr. 2015, pp. 528–533.

11. S. Sundaresan et al., "Broadband Internet performance: A view from the gateway," in Proc. ACM SIGCOMM, Aug. 2011, pp. 134–145.

12. V. Sivaraman, T. Moors, H. H. Gharakheili, D. Ong, J. Matthews, and C. Russell, "Virtualizing the access network via open APIs," in Proc. ACM ConNEXT, Dec. 2013, pp. 31–42.

13. Kok-Kiong Yap Te-Yuan Huang Ben Dodson Monica S. Lam Nick McKeown "Towards Software-Friendly Networks"Stanford University {yapkke,huangty,bjdodson,lam,nickm}@stanford.edu

14. Barbara van Schewick "Network Neutrality: What A Non-Discrimination Rule Should Look Like" Work presented at the 38th Research Conference on Communication, Information and Internet Policy (TPRC 2010) October 1 - October 3, 2010, Arlington, VA.

15. Erik Nordstr¨om, David Shue, PremGopalan, Robert Kiefer MatveyArye, Steven Y. Ko, Jennifer Rexford, Michael J. Freedman "Serval: An End-Host Stack for Service-Centric Networking"Princeton University.

16. Shwetasaibal Samanta Sahoo; Mousime Xalxo; B G Mukunda. "A Study on Tourist Behaviour Towards Sustainable Tourism in Karnataka". *International Research Journal on Advanced Science Hub*, 2, 5, 2020, 27-33. doi: 10.47392/irjash.2020.28

17. Muniyandy Elangovan; Mohamed Yousuf; Mohamed Nauman; Mohammed Nayeem. "Design and Development of Delivery Robot for Commercial Purpose". *International Research Journal on Advanced Science Hub*, 4, 07, 2022, 192-197. doi: 10.47392/irjash.2022.047

18. Manikandan N; Swaminathan G; Dinesh J; Manish Kumar S; Kishore T; Vignesh R. "Significant Attention in Industry and Academia for Wire Arc Additive Manufacturing (WAAM) - A Review". *International Research Journal on Advanced Science Hub*, 4, 07, 2022, 198-204. doi: 10.47392/irjash.2022.048

19. Shoeb Ahmed Syed; Steve Ales; Rajesh Kumar Behera; Kamalakanta Muduli. "Challenges, Opportunities and Analysis of the Machining Characteristics in hybrid Aluminium Composites (Al6061-SiC-Al2O3) Produced by Stir Casting Method". *International Research Journal on Advanced Science Hub*, 4, 08, 2022, 205-216. doi: 10.47392/irjash.2022.051

20. Ashima Saxena; Preeti Chawla. "A Study on the Role of Demographic Variables on Online Payment in Delhi NCR". *International Research Journal on Advanced Science Hub*, 4, 08, 2022, 217-221. doi: 10.47392/irjash.2022.052

21. Vishnupriya S; Nirsandh Ganesan; Ms. Piriyanga; Kiruthiga Devi. "Introducing Fuzzy Logic for Software Reliability Admeasurement". *International Research Journal on Advanced Science Hub*, 4, 09, 2022, 222-226. doi: 10.47392/irjash.2022.056

22. GANESAN M; Mahesh G; Baskar N. "An user friendly Scheme of Numerical Representation for Music Chords". *International Research Journal on Advanced Science Hub*, 4, 09, 2022, 227-236. doi: 10.47392/irjash.2022.057

23. Nirsandh Ganesan; Nithya Sri Chandrasekar; Ms. Gokila; Ms. Varsha. "Decision Model Based Reliability Prediction Framework". *International Research Journal on Advanced Science Hub*, 4, 10, 2022, 236-242. doi: 10.47392/irjash.2022.061

24. Vishnupriya S; Nithya Sri Chandrasekar; Nirsandh Ganesan; Ms. Mithilaa; Ms. Jeyashree. "Comprehensive Analysis of Power and Handloom Market Failures and Potential Regrowth Options". *International Research Journal on Advanced Science Hub*, 4, 10, 2022, 243-250. doi: 10.47392/irjash.2022.062

25. Minh Duc Ly; Que Nguyen Kieu Viet. "Improvement Productivity and Quality by Using Lean Six Sigma: A Case Study in Mechanical Manufacturing". *International Research Journal on Advanced Science Hub*, 4, 11, 2022, 251-266. doi: 10.47392/irjash.2022.066

26. Ragunath A; Poonam Syal. "Net Zero Energy Buildings Initiatives - A Review". *International Research Journal on Advanced Science Hub*, 4, 11, 2022, 267-271. doi: 10.47392/irjash.2022.067

27. Suresh P; Justin Jayaraj K; Aravintha Prasad VC; Abishek Velavan; Mr Gokulnath. "Deep Learning for Covid-19 Identification: A Comparative Analysis". *International Research Journal on Advanced Science Hub*, 4, 11, 2022, 272-280. doi: 10.47392/irjash.2022.068

28. Chirag H B; Darshan M; Rakesh M D; Priyanka D S; Manjunath Aradya. "Prediction of Concrete Compressive Strength Using Artificial Neural Network". *International Research Journal on Advanced Science Hub*, 4, 11, 2022, 281-287. doi: 10.47392/irjash.2022.069

29. Minh Ly Duc; Que Nguyen Kieu Viet. "Analysis Affect Factors of Smart Meter A PLS-SEM Neural Network". *International Research Journal on Advanced Science Hub*, 4, 12, 2022, 288-301. doi: 10.47392/irjash.2022.071

30. Lely Novia; Muhammad Basri Wello. "Analysis of Interpersonal Skill Learning Outcomes in Business English Students Class". *International Research Journal on Advanced Science Hub*, 4, 12, 2022, 302-305. doi: 10.47392/irjash.2022.072

31. Ms. Nikita; Sandeep Kumar; Prabhakar Agarwal; Manisha Bharti. "Comparison of multi-class motor imagery classification methods for EEG signals". *International Research Journal on Advanced Science Hub*, 4, 12, 2022, 306-311. doi: 10.47392/irjash.2022.073

32. Aniket Manash; Ratan Kumar; Rakesh Kumar; Pandey S C; Saurabh Kumar. "Elastic properties of ferrite nanomaterials: A compilation and a review". *International Research Journal on Advanced Science Hub*, 4, 12, 2022, 312-317. doi: 10.47392/irjash.2022.074

33. Prabin Kumar; Rahul Kumar; Ragul Kumar; Vivek Rai; Aniket Manash. "A Review on coating of steel with nanocomposite for industrial applications". *International Research Journal on Advanced Science Hub*, 4, 12, 2022, 318-323. doi: 10.47392/irjash.2022.075

34. Twinkle Beniwal; Vidhu K. Mathur. "Cloud Kitchens and its impact on the restaurant industry". International Research Journal on Advanced Science Hub, 4, 12, 2022, 324-335. doi: 10.47392/irjash.2022.076

35. T. Pravin, C. Somu, R. Rajavel, M. Subramanian, P. Prince Reynold, Integrated Taguchi cum grey relational experimental analysis technique (GREAT) for optimization and material characterization of FSP surface composites on AA6061 aluminium alloys, Materials Today: Proceedings,Volume 33, Part 8, 2020, Pages 5156-5161, ISSN 2214-7853. doi.org/10.1016/j.matpr.2020.02.863.

36. R. Ranjith, C. Somu, G. Tharanitharan, Venkatajalapathi.T, Naveenkumar M, Integrated Taguchi cum Grey Relational Experimental Analysis (GREAT) for Optimization and Machining Characterization of Cryogenic Cooled AA6063 Aluminium Alloys, Materials Today: Proceedings, Volume 18, Part 7, 2019,Pages 3597- 605, https://doi.org/10.1016/j.matpr.2019.07. 291.

37. R. Devi Priya, R. Sivaraj, Ajith Abraham, T. Pravin, P. Sivasankar and N. Anitha. "Multi-Objective Particle Swarm Optimization Based Preprocessing of Multi-Class Extremely Imbalanced Datasets". International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems Vol. 30, No. 05, pp. 735-755 (2022). Doi: 10.1142/S0218488522500209

38. M. S. N. K. Nijamudeen, G. Muthuarasu, G. Gokulkumar, A. Nagarjunan, and T. Pravin, “Investigation on mechanical properties of aluminium with copper and silicon carbide using powder metallurgy technique,” Advances in Natural and Applied Sciences, vol. 11, no. 4, pp. 277–280, 2017.

39. Pravin T, M. Subramanian, R. Ranjith,Clarifying the phenomenon of Ultrasonic Assisted Electric discharge machining, “Journal of the Indian Chemical Society”, Volume 99, Issue 10, 2022, 100705, ISSN 0019-4522, Doi: 10.1016/j.jics.2022.100705

40. V.S. Rajashekhar; T. Pravin; K. Thiruppathi , “Control of a snake robot with 3R joint mechanism”, International Journal of Mechanisms and Robotic Systems (IJMRS), Vol. 4, No. 3, 2018. Doi: 10.1504/IJMRS.2018.10017186

41. T. Pravin, M. Sadhasivam, and S. Raghuraman, “Optimization of process parameters of Al-10% Cu compacts through powder metallurgy,” Applied Mechanics and Materials, vol. 813-814, pp. 603–607, 2010.

42. Rajashekhar, V., Pravin, T., Thiruppathi, K.: A review on droplet deposition manufacturing- a rapid prototyping technique. Int. J. Manuf. Technol. Manage. 33(5), 362–383 (2019) https://doi.org/10.1504/IJMTM.2019.103277

43. Rajashekhar V S, Pravin T, Thirupathi K, Raghuraman S.Modeling and Simulation of Gravity based Zig-zag Material Handling System for Transferring Materials in Multi Floor Industries. Indian Journal of Science and Technology.2015 Sep, 8(22), pp.1-6.