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Optimizing Queueing Systems with N-Policy through Vedic Mathematical Techniques

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Abstract: Queuing theory is important for improving system performance in many fields, such as manufacturing, healthcare, and telecoms. But standard models are hard to compute, especially when dealing with very big systems. Using Queueing Theory, N-policy, and Vedic mathematics together in this paper is a new way of doing things. By starting service only when the number of entities hits a certain level, the N-policy approach makes better use of resources and cuts down on system idle times. With its efficient number theory, Vedic Mathematics makes complicated calculations easier. This makes the study of queueing models faster and less computer-intensive. By combining these methods, this paper shows how Vedic techniques make it easier to figure out data related to queues, like waiting times and system usage. The research looks at how the findings could be used in real life, looking at examples such as information networks, managing healthcare services, and manufacturing processes. This mix of different fields not only creates a new way to improve queueing systems, but it also shows how Indian Knowledge Systems can be used to solve modern math problems. Ultimately, this method gives us new ideas for how to make systems work better and use resources more wisely.

Keywords: Vedic Mathematics, N-Policy, Sutras, Sub-Sutras Queueing Theory

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INTRODUCTION

The ancient Indian Vedas inspired the intriguing topic of Vedic Mathematics. Complex mathematical methods are used. Rigveda, Yajurveda, Samaveda, and Atharvaveda, written 1500–900 BCE, contain vast information. These books give a complete mathematical framework for arithmetic, algebra, and geometry alternatives. Vedic Mathematics was meticulously documented and retained for millennia, largely orally before being written down. Between 1911 and 1918, Sri Bharati Krsna Tirthaji (1884-1960) developed Vedic Mathematics. Students can devise ways. Students become smarter, more creative, and engaged. Dhivyadeepa, Govindarajan Singaravelu (2013). The creator of Vedic mathematics claims Asian elders transmitted it till today, although there is no historical evidence. The survey report will be read. Future space missions and Vedic mathematics. (2022) (Raksha, Shetty, Kumar, M. Monisha). Exciting youngsters about math is hard. Teachers spend a lot of time engaging kids. Brief Vedic mathematics sessions should boost the experimental group's results and interest kids in math. Vedic Mathematics emphasizes speed, simplicity, and mental computation. Instead of step-by-step approaches and thorough documentation, Vedic maths stresses intuition and mental agility. This makes the Vedic technique perfect for addressing complex arithmetic problems fast. Vedic mathematics relies on sutras. Simple formulas with big mathematical concepts allow practitioners to calculate rapidly and mentally compute results. Vedic mathematics' ancient yet superb arithmetic and algebra methods have made it popular in the past decade. It shows how combining classical mathematics with cryptography might provide new digital communication security and data privacy solutions. Kumar, C R Suthikshn, (2024). Ancient Sulbasutras with geometric guidelines for building altars and other religious structures are the source of Vedic Mathematics. These pre-Western writings show a sophisticated understanding of mathematical ideas like the Pythagorean theorem. Vedic mathematics showed how knowledge was connected through numerical computations and philosophical and spiritual insights.To boost multiplier speed and reduce area and delay, Vedic Mathematics Sutras were researched. 2017(S. Shembalkar, S. Dhole, T. Yadav, P. Thakre). Vedic mathematics is relevant beyond history. Education, computing, and other industries are reintroducing it. Traditional math teaching seldom interests students and lowers arithmetic anxiety, but mental computation and pattern identification do. Vedic approaches can help students learn math and numbers. Due to their computational efficiency, Vedic algorithms appear promising in computer science. Vedic approaches can improve cryptography, data encryption, and error detection. Flexibility and adaptability make Vedic Mathematics ideal for building novel computational solutions. In a complicated environment, efficiency, accuracy, and optimization are crucial. Health care, transportation, manufacturing, telecommunications, and others manage systems, thus this is especially true. Queueing Theory, the mathematical study of queues, improves system performance. A service system's handling of people, jobs, and data packets is examined. Queueing Theory has been used in telephones, computer networks, and traffic systems. Despite its widespread use, computational inefficiencies and model complexity reduction remain.

N-Policy Queueing Models allow service to begin only when a particular number (N) of entities are in the system, which is creative. This model reduces activation costs and delays, improving resource allocation. Meanwhile, Vedic Mathematics, an ancient system of mathematical computation and problem-solving, offers several methods to simplify complex computations and speed up mathematical operations. Vedic methodologies like Sutra-based formulae make arithmetic issues intuitively solveable, making mathematical models quicker.

This research investigates how Queueing Theory, N-Policy, and Vedic Mathematics might be used to improve real-world systems. This study uses Vedic mathematics to increase queueing model calculation accuracy and performance. It enhances knowledge systems.

BACKGROUND

Overview of Queueing Theory

Queueing Theory deals with the study of queues (waiting lines), which appear in settings where demand for service exceeds the available service capacity. The theory offers a systematic method for studying systems where entities arrive at a service point, wait in line, and are finally processed or served.

Key Concepts of Queueing Theory

- **Arrival Process (λ)**: The speed at which customers or other objects join the line. It is usually described as a Poisson process, in which events are random but happen at a steady rate on average.
- **Service Process (μ)**: The rate at which a server or service center handles customers. An exponential distribution is frequently considered for the service times.
  - **Queue Length (L)**: The number of customers waiting in line for service.

- **Waiting Time (W)**: The time a customer spends waiting in the queue before receiving service.

Classic Queueing Models

- **M/M/1 Queue**: This is the most basic form of queueing model with a single server where both the arrival and service times are exponentially distributed (Markovian).
- **M/M/c Queue**: An extension of the M/M/1 model, where there are **c** servers working in parallel.
- **M/G/1 Queue**: A model where the service time follows a general distribution.

Queuing models are very important in many fields, like telecoms, where data bits are processed, hospitals, where patients wait for care, and manufacturing systems, where things are made and processed at different stages.

N-Policy in Queueing Theory

With the N-Policy, service is only started when the number of customers (or entities) in the system hits a certain number N. This is different from the usual queueing system. In this case, the server doesn't start processing customers until there are at least N of them in the system. This makes better use of the service capacity. If starting a service costs money or takes a lot of time, the N-Policy method can be very helpful. This is because it lets you wait until a certain benchmark is met before starting the service.

Mathematical Formulation of N-Policy Models

Consider a **single-server queueing system** with an **N-Policy**. The key features are:

- **Arrival rate (λ)**: The rate at which customers arrive at the system.
- **Service rate (μ)**: The rate at which customers are served.
- **N (Threshold value)**: The number of customers required in the system before service begins.

The system can be modeled as a **birth-death process** with the following states:

- When the number of customers in the system is less than **N**, no service occurs.
- Once the number of customers in the system reaches or exceeds **N**, the server starts processing the customers.

To find the steady-state probabilities, average wait times, and queue lengths, the system is modeled mathematically using Markov Chains and Laplace Transforms. Equations derived from Poisson processes and Markov processes can be used to look at how well this model works. For example, a recursive relation that adds the threshold value N to the classical queueing equations can be used to find the steady-state probability distribution for an N-policy system.

VEDIC MATHEMATICS: A GLIMPSE INTO ANCIENT WISDOM

Core Principles of Vedic Mathematics

According to the Vedas, Vedic Mathematics offers a collection of computational methods based on sub-sutras (derivative formulae) and sutras (short formulas). By lowering the number of steps needed to solve a problem, these sutras frequently simplify arithmetic processes and enable quick and mental computation of difficult mathematical problems.

The entire mechanics of Vedic mathematics is based on 16 sutras and 13sub-sutras.

The thirteen sub-sutras are along with their brief meaning are enlisted as:

1. Anurupyena :- Equilibrium.
2. SisyateSesasamjnah :-“Remainder remains constant”.
3. Adyamadyenantya-mantyena :-“First by the first and last by the last”.
4. KevalaihSaptakamGunyat :-“For 7 the multiplicand is 143”.
5. Yavadunam Tavadunikritya Varganca Yojayet :-“Whatever the deficiency lesson by that amount and set up the square of the deficiency”.
6. Antyayordasakae’pi :- It means which numbers the last digit sum is give 10.
7. Vestanam :-“By osculation”.
8. YavadunamTavadunam :- Lessen by the insufficiency.
9. Antyayoreva :- At most the rearmost term.
10. Samuccayagunitah :-“The sum of the coefficients in the product”.
11. Lopanasthapanabhyam :- By alternative eradication and retention.
12. Vilokanam :- By trivial examination.
13. Gunitasamuccayah Samuccayegunitah :- “The product of the sum is the sum of the product”.

And the Sutras along with their brief meanings are enlisted below.

1. Ekadhikina Purvena – Add one number from the previous number.
2. Nikhilam Navatashcaramam Dasatah – we take all numbers from base 9 and last number from base 10.
3. Urdhva-tiryagbhyam- Perpendicular and diagonally.
4. Sankalana-vyavakalanabhyam – By adding and by decrement.
5. Puranapuranabyham – By the accomplishment or incompletion.
6. Vyashtisamastih – Segment and total.
7. SesanyankenaCaramena – The residue by the rearmost number.
8. Calana-Kalanabhyam – Distinction and likeness.

9. Yaavadunam – “Whatever the extent of its deficiency”.
10. ParavartyaYojayet – Interchange and adjust.
11. Sunyam-Samyasamuccaye – “When the sum is the same that sum is zero”.
12. (Anurupye) Sunyamanyat – “If one is in ratio, the other one is zero”.
13. Sopantyadvayamantyam – The eventual and twice the consequent.
14. Ekanyunena Purvena – Subtract one number from the previous number.
15. Gunitasamuccayah – “The product of the sum is equal to the sum of the product”.
16. Gunakasamuccayah –“The factors of the sum is equal to the sum of the factors”.

Key Sutras in Vedic Mathematics include:

1. **Nikhilam Sutra**: This method involves solving subtraction problems by subtracting from a base number (typically a power of 10). It is particularly useful for quickly performing addition and subtraction operations.
2. **Urdhva-Tiryak Sutra**: This is a vertical and crosswise method for multiplying numbers. It simplifies the multiplication of large numbers by breaking them down into smaller operations.
3. **Ekadhikena Purvena**: This sutra is used for squaring numbers that are near a base value (e.g., numbers close to 100 or 1000).
4. **Paravartya Sutra**: This method is used for division problems, reducing the complexity of long division.

These methods are very fast and accurate, which makes them perfect for making current computers work better, especially when they have to deal with complicated math problems like those found in Queueing Theory.

INTEGRATING N-POLICY AND VEDIC MATHEMATICS

Speeding Up Queueing Calculations

Combining N-Policy with Vedic Mathematics creates a one-of-a-kind chance to improve the speed and difficulty of computing in queueing systems. We will look at how Vedic mathematics can be used to make the calculations for N-Policy queueing models easier in this part.

Queueing systems often involve complex arithmetic, including calculating the waiting time, queue length, and system utilization. The following Vedic techniques can be employed to enhance these calculations:

- **Multiplication by 11 (Vedic Sutra)**: When calculating factors related to service rates or arrival rates, the multiplication by 11 sutra can be used to speed up the computation process.
- **Nikhilam Sutra**: When dealing with arrival or service rates that are close to a power of 10, this sutra can be employed to simplify the process of adding or subtracting rates.

· **Urdhva-Tiryak Sutra**: This technique can be applied to multiply large numbers that arise in the calculation of queue lengths, especially in cases involving multiple servers or large system populations.

By using these techniques, we can reduce the time complexity of solving equations, which would otherwise require lengthy manual computation or computational software.

Example: Queue Length Prediction Using Vedic Mathematics

In a queueing system, predicting the average queue length is an important task. The formula for **L (queue length)** in a standard **M/M/1** queue can be written as:

$$L = \frac{\lambda}{\mu - \lambda}$$

Where **λ** is the arrival rate, and **μ** is the service rate. In more complex N-policy systems, the computation becomes much more intricate due to the threshold value **N**. Using Vedic techniques, we can simplify the arithmetic involved in solving this equation.

APPLICATIONS OF N-POLICY WITH VEDIC MATHEMATICS

1. Telecommunications and Data Networks

Data packets arrive at a server at a predetermined rate in contemporary telecommunications networks, and the server processes these packets using a queueing mechanism. In the process of putting into action an N-policy, the server may decide to select to begin processing data only after a predetermined number of packets have been received. Vedic mathematics allows telecommunications firms to optimize the flow of data, so minimizing delays and enhancing throughput. Vedic mathematics may be used to determine arrival and service rates, as well as to estimate queue lengths.

2. Healthcare Systems

Patients who are waiting for various services at hospitals, such as consultations or laboratory testing, frequently have to wait for excessively lengthy periods of time. Once a sufficient number of patients have come for a given treatment, hospitals are able to begin providing that service by adopting a model known as an N-policy. Vedic approaches can assist simplify the computation of service prices and waiting times, enhancing efficiency and patient satisfaction

ADVANTAGES AND CHALLENGES

Advantages

Enhanced Computational Efficiency: Vedic mathematics makes mathematical operations easier to understand, which enables users to do computations in queueing models more quickly, particularly in real-time networks.

Optimized Resource Utilization: The N-policy approach enhances resource allocation by minimizing idle time and wasteful service commencement.

Interdisciplinary Innovation: Putting together old Indian knowledge with modern mathematical methods gives us a new way to look at how to make modern processes work better.

Challenges

Complexity in Real-World Applications: Although N-policy models are theoretically useful, their practical application can be difficult, particularly in extensive and intricate systems.

Adoption of Vedic Techniques: Even though Vedic mathematics is very useful, it might take some training and knowledge of old techniques to use it in current computers.

FUTURE DIRECTIONS

Future research in this field could explore:

- **Optimization Algorithms**: using advanced machine learning algorithms to make mixed models even better.
- **Real-Time Systems**: In real-time systems like IoT and Smart Cities, N-policy models are being used to make things work.
- **Quantum Computing**: Looking into how quantum computing can make it easier to use N-policy and Vedic mathematics in big systems.

CONCLUSION

Both the discipline of Operations Research and the field of Indian Knowledge Systems stand to benefit from the exciting prospect presented by the combination of Queuing Theory with N-policy and Vedic Mathematics. In this research, we demonstrate how we may enhance system efficiency and computing time by integrating old computational approaches with current mathematical models. This will ultimately result in applications that are optimized for use in the actual world where they are implemented. The implementation of this multidisciplinary approach paves the way for new research and application opportunities in the fields of technology, economics, and healthcare, which will contribute to the development of computational systems in the future across a variety of sectors.

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