The Fibonacci Sequence and Golden Ratio in Network Load Balancing

Your Name

1 Introduction

- Hook: The surprising application of Fibonacci sequence and golden ratio in network load balancing

- Thesis: The Fibonacci Multipath Load Balancing (FMLB) protocol demonstrates the power and beauty of applying mathematical concepts to practical problems

- Roadmap: Overview of the essay's structure

2 Background

1. The Fibonacci Sequence

   (a) Definition and first few terms

   (b) Recursive formula

   (c) Relationship to the golden ratio

   [Add an image illustrating the Fibonacci sequence and its relation to the golden ratio]

2. The Golden Ratio

   (a) Definition and value

   (b) Appearance in nature and art

   [Add an image showing examples of the golden ratio in nature or art]

3. Mobile Ad Hoc Networks (MANETs)

   (a) Definition and characteristics

   (b) Routing challenges, especially congestion

   [Add an image depicting a MANET topology]

3 Summary of the Scientific Paper

- Problem addressed: Congestion in MANETs

- Proposed solution: Fibonacci Multipath Load Balancing (FMLB) protocol

  1. Key idea: Distribute load across multiple paths using Fibonacci sequence
     (1) "To improve the packet delivery ratio, the authors propose a novel load balancing scheme called the Fibonacci Multipath Load Balancing (FMLB) protocol.
     (2) The key idea is to discover multiple paths between the source and destination nodes and distribute the transmitted packets across these paths using the Fibonacci sequence (Tashtoush et al., 2014, p. 239)."

  2. Protocol operation: Discover paths, assign weights, allocate packets
     (1) "Specifically, the available paths are sorted in increasing order of length (number of hops).
     (2) Each path is then assigned a Fibonacci number based on its position in this sorted list - the shortest path gets the largest Fibonacci number and so on (Tashtoush et al., 2014, p. 240)."

  [Add an image illustrating the FMLB protocol's operation]

- Results: Improved packet delivery ratio and reduced delay compared to other protocols *[Add an image showing comparative performance graphs]*

  (1) "The simulation results show that the FMLB protocol has achieved an enhancement on packet delivery ratio, up to 21%, as compared to the Ad Hoc On-demand Distance Vector routing protocol (AODV) protocol,
  (2) and up to 11% over the linear Multiple-path routing protocol." (Tashtoush et al., 2014, p. 237)

4 Connection to Fibonacci Numbers

- How the FMLB protocol uses Fibonacci sequence

  1. Paths sorted by length and assigned Fibonacci weights
  2. Packets allocated proportional to weights

  [Add an image visualizing the packet distribution according to Fibonacci weights]

(1) "The FMLB protocol's responsibility is balancing the packets transmission over the selected paths and ordering them according to hops count.

(2) The shortest path is used more frequently than the other ones." (Tashtoush et al., 2014, p. 237)

- Mathematical properties of Fibonacci numbers relevant to load balancing

  1. Fibonacci sum identity

  $$F_1 + F_2 + \cdots + F_n = F_{n+2} - 1$$

  Note: This identity shows that the sum of the first n Fibonacci numbers is one less than the $(n+2)$-th Fibonacci number.

  2. Fibonacci ratios and the golden ratio

  $$\lim_{n \to \infty} \frac{F_{n+1}}{F_n} = \varphi \approx 1.618$$

  Note: This limit shows that the ratio of successive Fibonacci numbers converges to the golden ratio φ.

- Significance of using Fibonacci numbers in this context

  1. Efficient and balanced load distribution

  2. Inherent optimality and self-similarity properties

Proposition 1. *The FMLB protocol's use of Fibonacci numbers for path weights results in an optimal and balanced distribution of load across available paths.*

(1) "Through analysis and simulations, the authors show that this Fibonacci-based load balancing approach achieves significant gains in packet delivery compared to standard single-path routing

(2) as well as other multi-path schemes (Tashtoush et al., 2014, p. 243-244)."

(1) "Therefore, in an example with 5 paths, the ratios of the packets allocated is roughly:

(2) F5 : F4 : F3 : F2 : F1 = 5/12 : 3/12 : 2/12 : 1/12 : 1/12

(3) ≈ 0.416 : 0.25 : 0.166 : 0.083 : 0.083

(4) ≈ 1.618 : 1 : 0.618 : 0.382 : 0.382

(5) (Derived from the Fibonacci weights used in Tashtoush et al., 2014, p. 240)."

5 Connection to the Golden Ratio

- Emergence of the golden ratio in the FMLB protocol

  1. Ratio of packets allocated to successive paths
  2. Convergence to the golden ratio as number of paths increases

  [Add an image showing the convergence of packet allocation ratios to the golden ratio]

  (1) "With more paths, the ratio of packets allocated to successive paths approaches the golden ratio.
  (2) For instance, with 10 paths, the load allocation fractions are:
  (3) F10 : F9 : F8 : F7 : F6 : F5 : F4 : F3 : F2 : F1
  (4) $= 55/143 : 34/143 : 21/143 : 13/143 : 8/143 : 5/143 : 3/143 : 2/143 : 1/143 : 1/143$
  (5) $\approx 0.385 : 0.238 : 0.147 : 0.091 : 0.056 : 0.035 : 0.021 : 0.014 : 0.007 : 0.007$
  (6) (Derived from the Fibonacci weights used in Tashtoush et al., 2014, p. 240)."

- Significance of the golden ratio

  1. Appearance in optimization problems
  2. Connection to natural patterns and processes

  Proposition 2. *The golden ratio φ appears in many optimization problems and natural phenomena, suggesting its significance in efficient and balanced systems.*

- Implications of the FMLB protocol's relation to the golden ratio

  1. Optimality and efficiency of the load balancing approach
  2. Link between network optimization and natural optimization

  Note: The emergence of the golden ratio in the FMLB protocol suggests a deep connection between network optimization and the optimization principles found in nature.

6 Conclusion

- Recap of the main points

  1. FMLB protocol's use of Fibonacci numbers and golden ratio
  2. Improved performance and optimality of this approach

- Broader significance

  1. Power of applying mathematical concepts to practical problems
  2. Deep connection between mathematics, nature, and technology

     "Tashtoush et al.'s work demonstrates that mathematical beauty and practical application need not be distant ideas - they can come together in harmony to advance the frontiers of networking research (Tashtoush et al., 2014)."

- Final thoughts and future directions

  1. Potential for further exploration and application of these ideas
  2. Importance of interdisciplinary thinking and collaboration

[Add a concluding image that symbolizes the connection between Fibonacci numbers, the golden ratio, and network optimization]