ΠΑΡΟΥΣΙΑΣΗ
ΔΙΔΑΚΤΟΡΙΚΗΣ ΔΙΑΤΡΙΒΗΣ

ΗΜΕΡΟΜΗΝΙΑ: Πέμπτη, 27 Απριλίου 2023

ΩΡΑ: 09:00 – 10:30

ΑΙΘΟΥΣΑ: Η παρουσίαση θα πραγματοποιηθεί στην Αίθουσα Σεμιναρίων του ΤΜΗΥΠ

ΟΜΙΛΗΤΗΣ: **Χρυσάνθη Κοσυφάκη**

Θ έ μ α

«Flow Analytics in Large Graphs»

Επταμελής Εξεταστική Επιτροπή:

1. **Nikos Mamoulis**, Professor, Department of Computer Science and Engineering, University of Ioannina
2. **Evaggelia Pitoura**, Professor, Department of Computer Science and Engineering, University of Ioannina
3. **Panayiotis Tsaparas**, Assoc. Professor, Department of Computer Science and Engineering, University of Ioannina
4. **Reynold Cheng**, Professor, Department of Computer Science, The University of Hong Kong
5. **Ben Kao**, Professor, Department of Computer Science, The University of Hong Kong
6. **Dimitris Papadias**, Professor, Department of Computer Science and Engineering, Hong Kong University of Science and Techology
7. **Matthias Renz**, Professor, Department of Computer Science, CAU University of Kiel

ΤΜΗΜΑ ΜΗΧΑΝΙΚΩΝ Η/Υ & ΠΛΗΡΟΦΟΡΙΚΗΣ
ΠΑΝΕΠΙΣΤΗΜΙΟ ΙΩΑΝΝΙΝΩΝ
Τ.Θ. 1186, ΙΩΑΝΝΙΝΑ 45110
Τ: 265100 8817 - 8813 - 7196
http:/www.cse.uoi.gr/

DEPT. OF COMPUTER SCIENCE & ENGINEERING
UNIVERSITY OF IOANNINA
P.O. BOX 1186, IOANNINA
GR - 45110 GREECE
T: +30 265100 8817 - 8813 - 7196
http:/www.cse.uoi.gr/

Π ε ρ ί λ η ψ η:

Numerous real-world applications can be represented as networks of dynamic structure, since the vertices correspond to entities that exchange data over time. Examples include transportation networks, financial networks, social networks, traffic networks etc. We call these *Temporal Interaction Networks (TINs)*. The importance of studying and analyzing TINs is high as we can use them to solve problems related to transportation and financial transactions. Moreover, analyzing TINs can extract interesting insights or reveal important information (e.g., cyclic transactions, message interception).

TINs capture the data transfers between entities along a timeline. Specifically, at each interaction, a quantity (money, message, traffic) moves from one network vertex (entity) to another. We call this quantity *flow*. The main objective of this thesis is to introduce and analyze the flow concept in a variety of problems (flow computation, tracking the provenance of a quantity, extracting patterns etc.). Flow analysis in TINs can be used for congestion detection and explanation in traffic networks, identification of suspicious transactions in financial networks, to name a few applications. It also comes with a number of challenges and difficulties, most notably the potentially large graph size and huge number of interactions between the vertices of the TIN. Another issue is that solutions to well-studied problems in graphs, such as max-flow computation in static networks, cannot directly be applied to solve flow computation problems in TINs. Hence, it is necessary to design novel, scaleable, and memory-efficient solutions for this problem.

In this thesis, we introduce and study a number of flow computation problems in TINs. In the first part of the thesis, we study the problem of computing in a subgraph (DAG) of the TIN the total flow from a designated source node to a designated sink node. Specifically, for this problem we propose and study two models of flow computation. The first model is a greedy flow transfer approach where each interaction transfers the maximum possible quantity. The second model is an approach inspired from the maximum flow computation problem. In this case, the interactions may not transfer the maximum possible quantity, but

ΤΜΗΜΑ ΜΗΧΑΝΙΚΩΝ Η/Υ & ΠΛΗΡΟΦΟΡΙΚΗΣ
ΠΑΝΕΠΙΣΤΗΜΙΟ ΙΩΑΝΝΙΝΩΝ
Τ.Θ. 1186, ΙΩΑΝΝΙΝΑ 45110
Τ: 265100 8817 - 8813 - 7196
http:/www.cse.uoi.gr/

DEPT. OF COMPUTER SCIENCE & ENGINEERING
UNIVERSITY OF IOANNINA
P.O. BOX 1186, IOANNINA
GR - 45110 GREECE
T: +30 265100 8817 - 8813 - 7196
http:/www.cse.uoi.gr/

the one which results in the maximum flow transfer from the source to the sink along the timeline. This problem can be formulated and solved as a linear programming (LP) problem. We propose a number of preprocessing and graph simplification techniques that greatly reduce the complexity of the problem in practice. Lastly, we propose algorithms that enumerate DAG pattern instances and their flows in large graphs.

The second problem we study is flow provenance tracking in TINs. Specifically, given a node in the graph, we study the provenance of the total quantity that has been accumulated at the node by a time instant. We study provenance under a number of different models for the propagation of quantities; for each such model we define an annotation generation and propagation algorithm that can be used to track provenance. We also propose scaleable techniques for the most expensive model (propagation selection) in large graphs and analyze the space and time complexity of the provenance mechanisms that we propose.

In the last part of this thesis, we introduce spatio-temporal flow patterns of passengers in transportation networks. We study the problem of identifying interesting origin-destination-time (ODT patterns) at varying granularity. We propose algorithm for extracting such patterns efficiently. We also propose a number of optimizations to our baseline algorithm, which significantly reduce the time spent for generating candidate patterns and counting their support. Since the pattern enumeration can still be expensive, we propose practical variants of pattern search.

For our evaluation, we use a number of real datasets from different application domains (e.g., bitcoin exchange network, passenger transportation network, loan exchange network) of varying scales and densities. Our results show that our proposed algorithms are scaleable and that their output can be useful in many applications of flow analysis in temporal networks.

ΤΜΗΜΑ ΜΗΧΑΝΙΚΩΝ Η/Υ & ΠΛΗΡΟΦΟΡΙΚΗΣ
ΠΑΝΕΠΙΣΤΗΜΙΟ ΙΩΑΝΝΙΝΩΝ
Τ.Θ. 1186, ΙΩΑΝΝΙΝΑ 45110
Τ: 265100 8817 - 8813 - 7196
http:/www.cse.uoi.gr/

DEPT. OF COMPUTER SCIENCE & ENGINEERING
UNIVERSITY OF IOANNINA
P.O. BOX 1186, IOANNINA
GR - 45110 GREECE
T: +30 265100 8817 - 8813 - 7196
http:/www.cse.uoi.gr/