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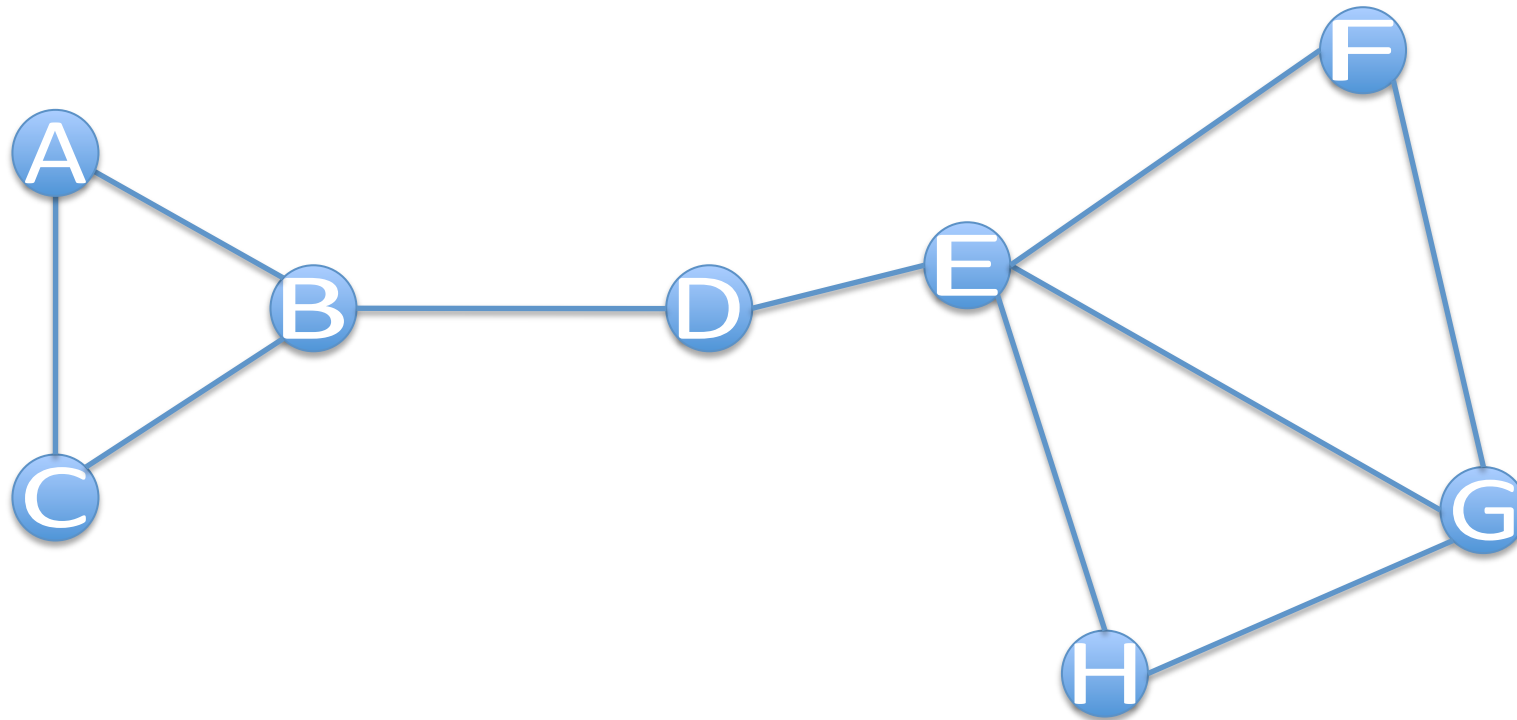
Computer Laboratory

Temporal Distance Metrics for Network Analysis

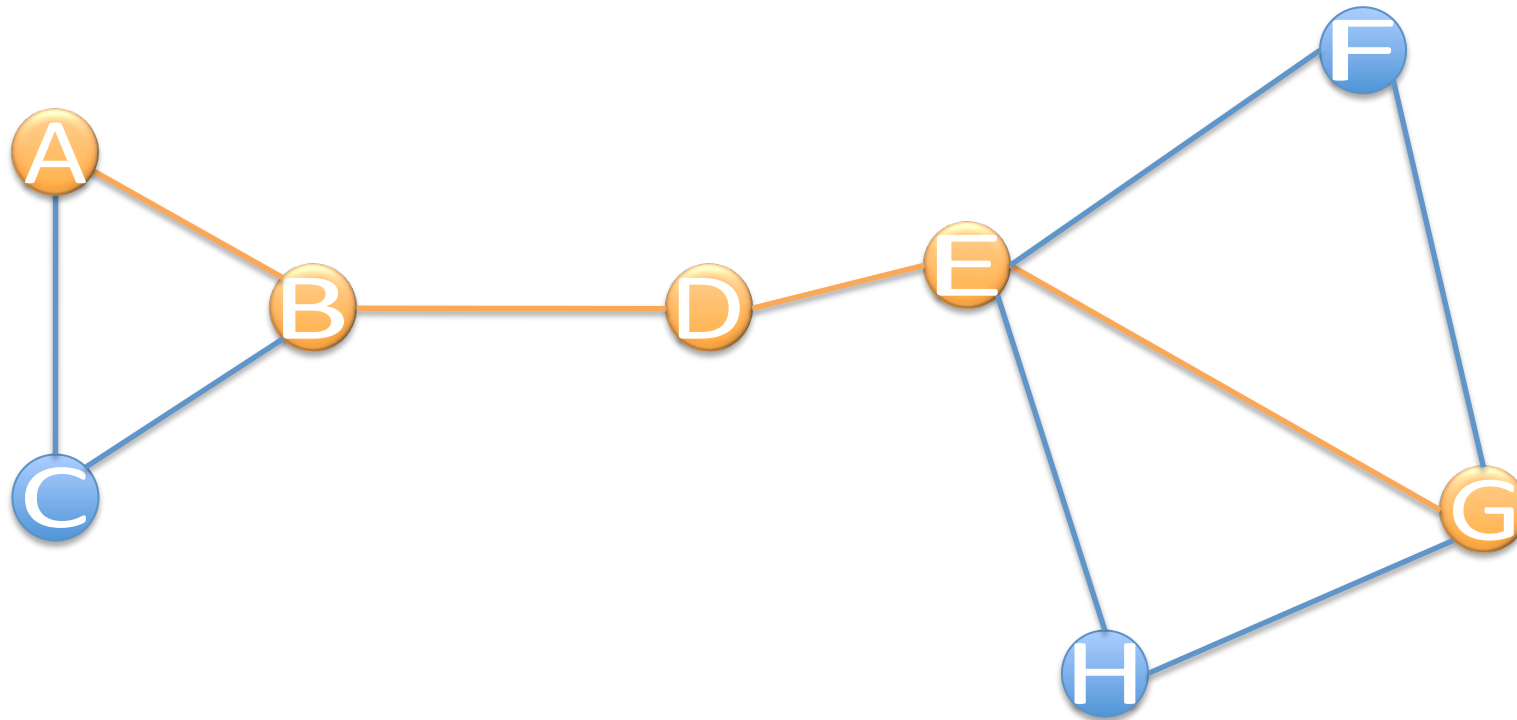
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Work with Mirco Musolesi, Cecilia Mascolo & Vito Latora

Motivation



Motivation



Shortest path (A,G) = [A,B,D,E,G]

Shortest path length (A,G) = 4 hops

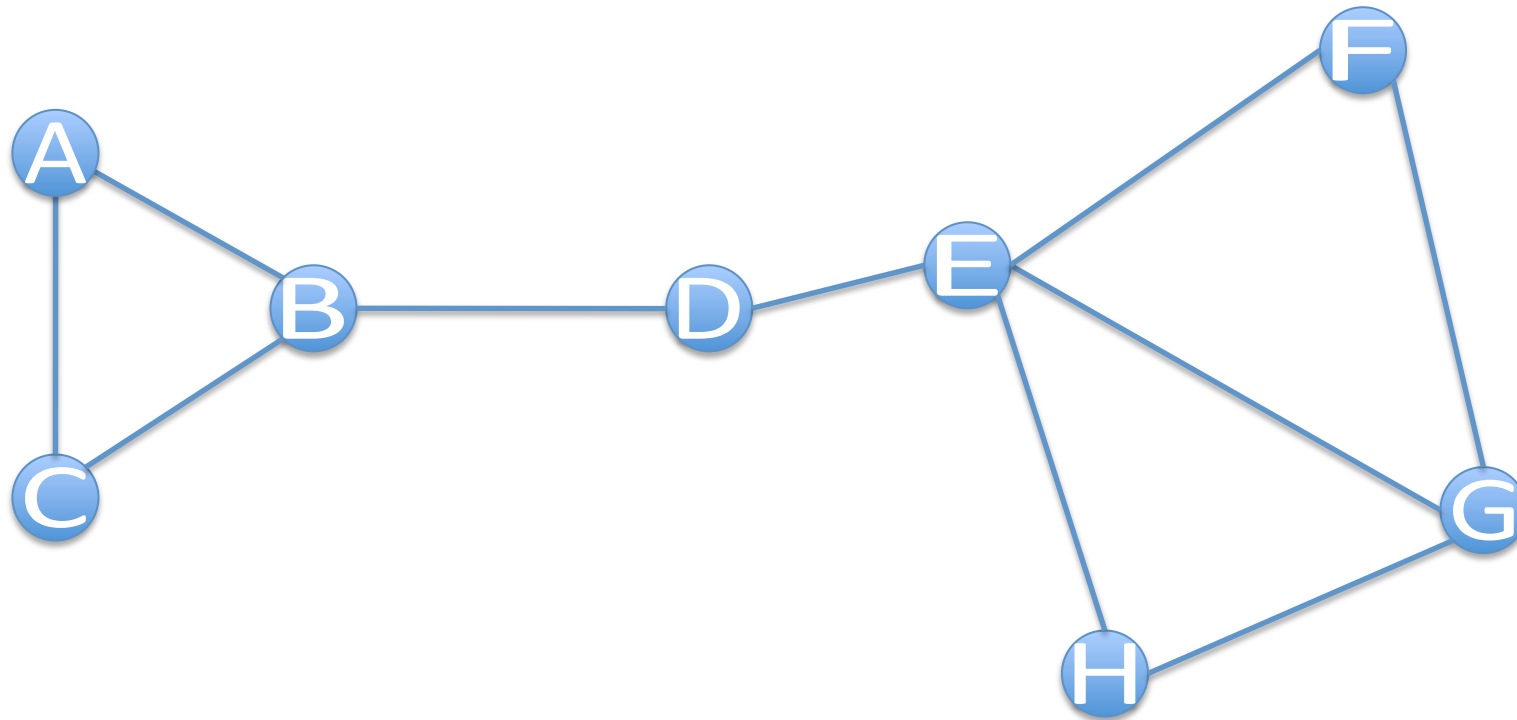
Motivation

- Assumptions
 - Links always available?
 - Nodes always available?
 - Concurrently available?

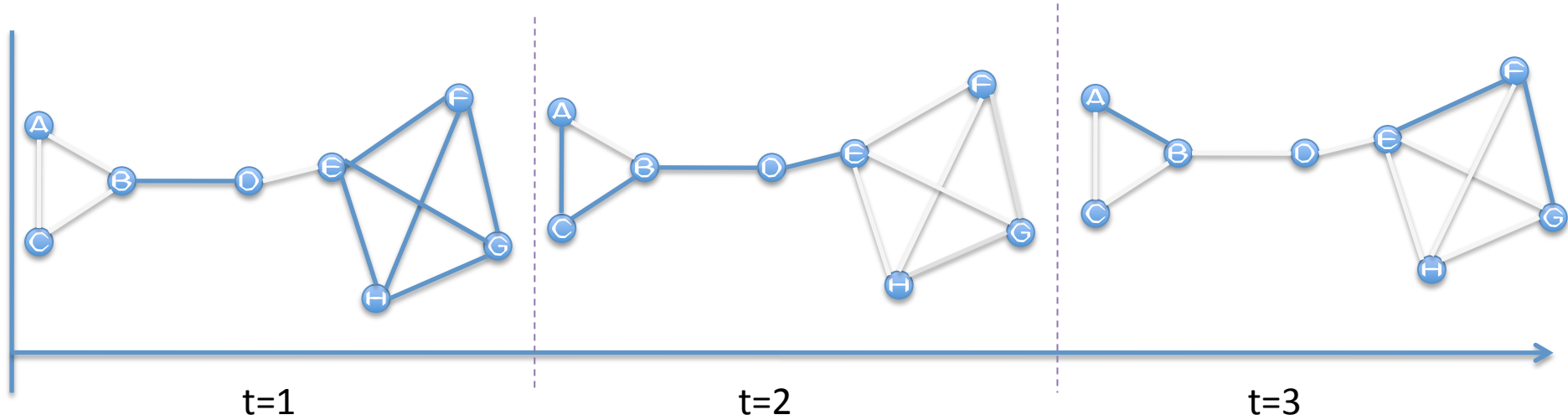
Real Networks

	Node	Edges
Social Network	People	Meetings
Computer Network	Router	Links
Ecological Food Network	Species	Predator-prey
Traffic Network	Traffic Light Junction	Roads

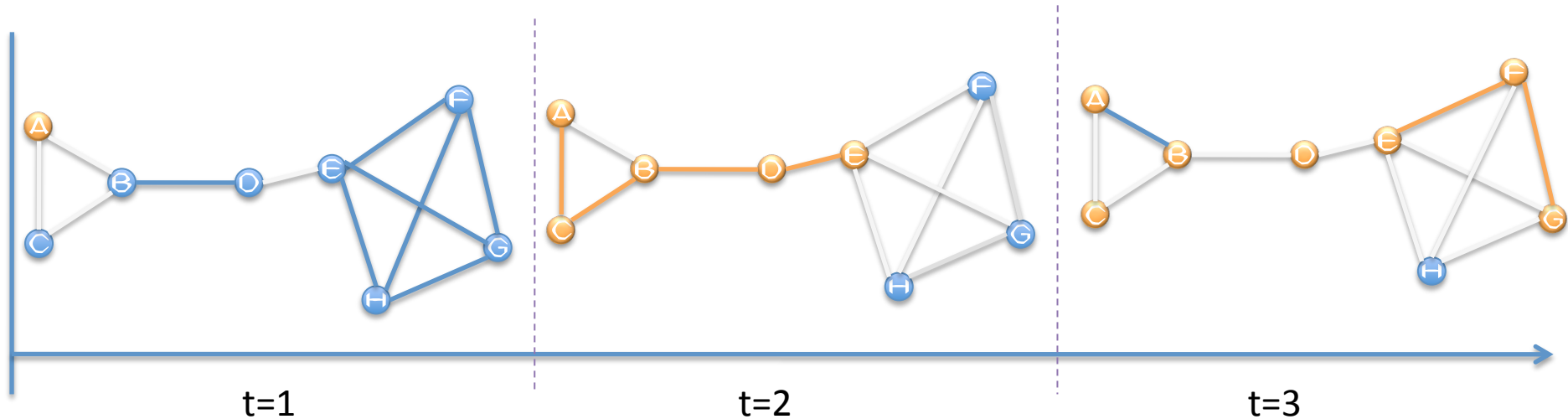
Static Graph



Temporal Graph



Temporal Graph



- Static

- Shortest path (A,G) = [A,B,D,E,G]
- Shortest path length (A,G) = 4 hops

- Temporal

- Shortest path (A,G) = [A,C,B,D,E,F,G]
- Shortest path length (A,G) = 7 hops
- Time=3 seconds

Recap

- Static Analysis is insufficient
- Temporal Properties
 - Time order
 - Duration
 - Frequency

Recap

- Static Analysis is insufficient
- Temporal Properties
 - Time order
 - Duration
 - Frequency
- Any difference in real network traces?

Temporal Metrics

- d_{ij} Shortest Temporal Path Length
- d_{ij}^* Shortest Path with temporal constraints
- $E_{ij} = \frac{1}{d_{ij}}$ Temporal Efficiency

Temporal Metrics

- Average Temporal $L = \frac{1}{N(N-1)} \sum_{ij} d_{ij}$
- Average Temporal $L^* = \frac{1}{N(N-1)} \sum_{ij} d_{ij}^*$
- Average Efficiency $E_{glob} = \frac{1}{N(N-1)} \sum_{ij} E_{ij}$

Evaluation

- Infocom 2005
- Bluetooth colocation scans
- 5 Minute Windows
- Measure 24 hours starting 12am

					Static		Temporal		
Day	N	<k>	Activity	Contacts	L	Eglob	L*	L	Eglob
1	37	25.73	6pm-12pm	3668	1.291	0.856	4.090	19h 39m	0.003
2	39	28.31	12am-12pm	8357	1.269	0.870	4.556	9h 6m	0.024
3	38	22.32	12am-12pm	4217	1.420	0.798	4.003	10h 32m	0.018
4	39	21.44	12am-5pm	3024	1.444	0.781	4.705	9h 55m	0.013

Conclusions

- Static
 - Overestimate available hops
 - Underestimates shortest paths
- Temporal
 - Time order
 - Indication of time

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J. Tang, M. Musolesi, C. Mascolo, V. Latora, “Temporal Distance Metrics for Social Network Analysis”, ACM SIGCOMM WOSN09. August 2009.