Progettazione di Protocolli di Network Forming Ispirati alla Biologia per Applicazioni di Vehicular Fog Computing

Bio-inspired Network Forming Protocols Design Applied to Vehicular Fog Computing

Relatore:
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Candidato:
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Correlatore:
Dott. Alessio Bonadio

Firenze – 11/10/2018

Indice

VANET e Vehicular Fog Computing

VANETs

- Vehicular Ad-hoc NETworks (P2P)
- Uso di OBU (On Board Unit) ed RSU (Road Side Unit)
- Comunicazione di tipo V2V e V2I

Motivi e vantaggi

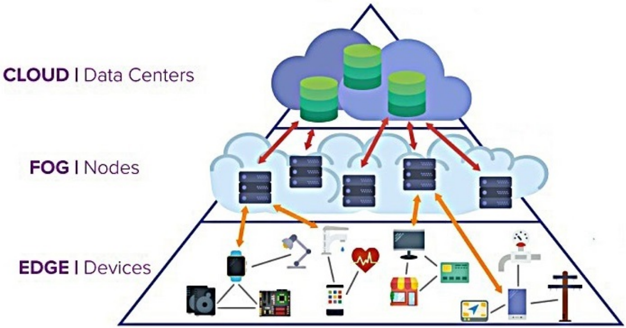
- Sicurezza del veicolo
- Tecnologia predittiva
- Consumo energetico

Edge Computing

- Informazioni prodotte ed elaborate ai margini della rete
- Device eterogenei

VANET e Vehicular Fog Computing

Fog Computing



- VANET + Fog Computing $\Rightarrow$ Vehicular Fog Computing

Network Forming - Analogia batteri/veicoli

Problemi riscontrati

- Quale logica adottare?
- Quali motivi spingono i veicoli a connettersi fra loro?

Soluzioni ispirate alla biologia

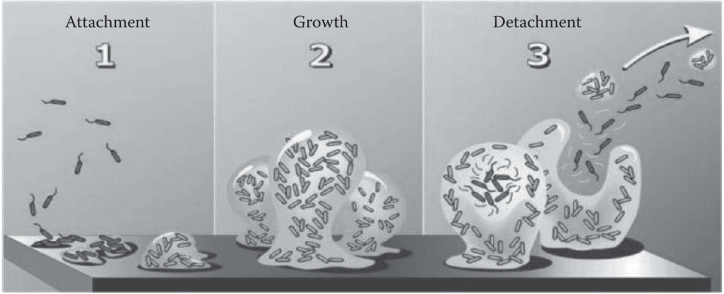
- Colonie Batteriche
- Modello stabile (basato sulla teoria dei giochi) [1]

[1] L. Canzian, K. Zhao, G.C.L. Wong, M. van der Schaar, 'A dynamic network formation model for understanding bacterial self-organization into micro-colonies', IEEE Transactions on Molecular, March 2015

Network Forming - Analogia batteri/veicoli

Fasi di creazione della colonia batterica:

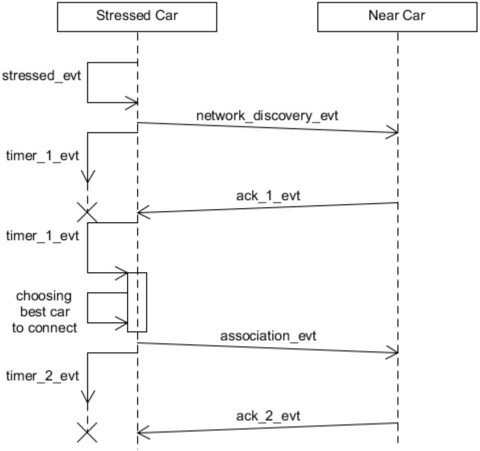
- Stress individuale
- Ricerca batteri vicini
- Connessione se benefici $>$ costi



Modello protocollare

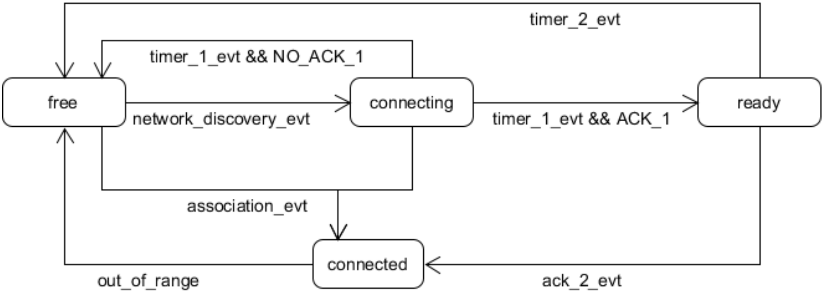
Fasi di creazione della VANET:

1. Stress del veicolo
2. Network Discovery
3. Invio di informazioni
4. Scelta della miglior connessione
5. Richiesta di associazione
6. Messaggio di Acknowledgement



Modello protocollare

Macchina a stati finiti relativa al protocollo



Tools per simulazioni veicolari

OMNeT++

- Framework C++
- Simulazioni di rete
- Interfaccia grafica intuitiva
- Reti completamente personalizzabili

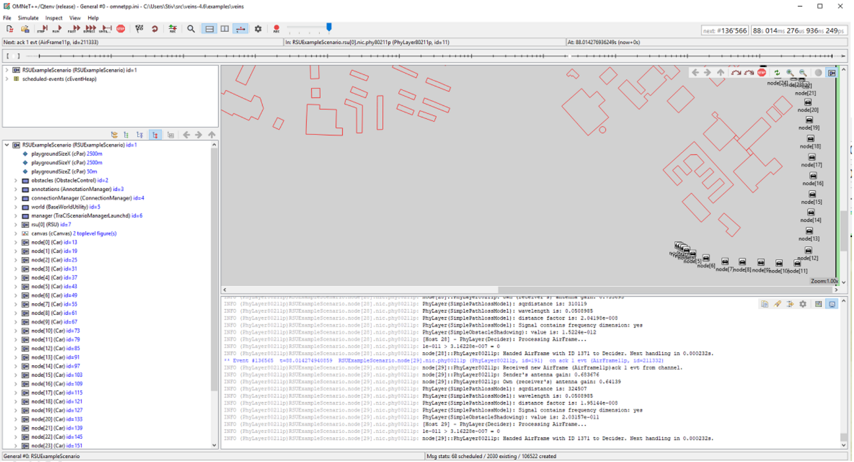
SUMO (Simulation of Urban MObility)

- Simulazioni di reti stradali
- Dettagli a livello microscopico

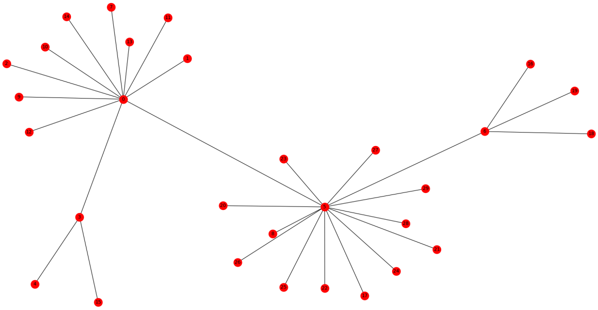
Veins (VEhicles In Network Simulation)

- Potenzialità di OMNeT++ e SUMO
- Modifiche dei livelli protocollari

Scenario di simulazione



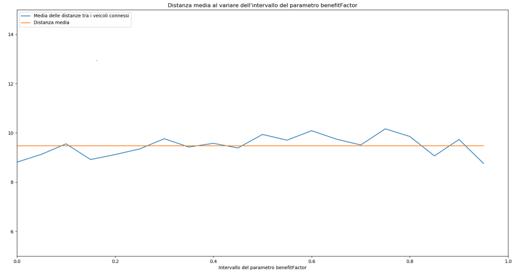
Risultati sperimentali



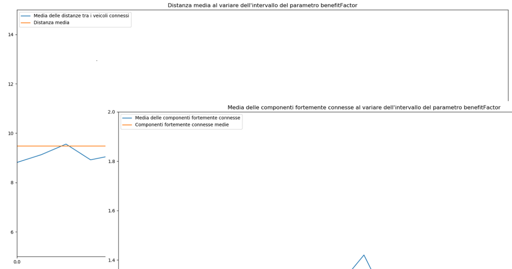
Misurazioni:

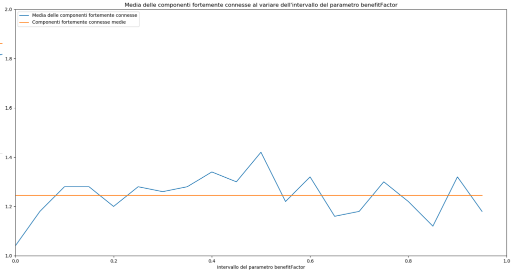
1. Media delle distanze tra i nodi connessi direttamente
2. Numero di componenti fortemente connesse
3. Branching Factor medio
4. Numero medio di hop tra veicoli casuali

Risultati sperimentali - intervallo di *benefitParameter* variabile (ampiezza = 0,05)

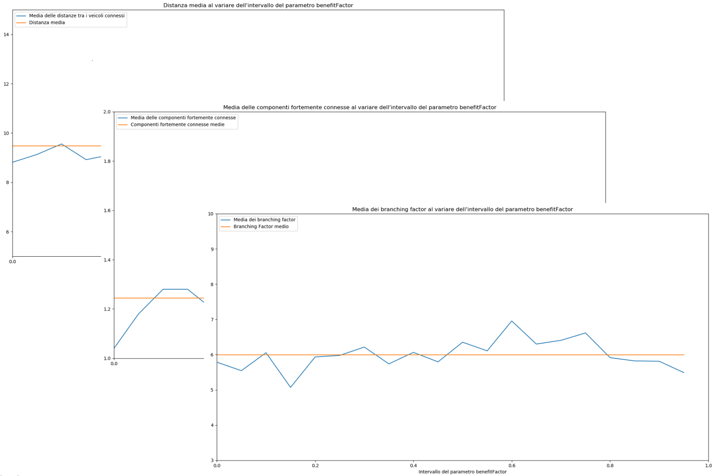


Risultati sperimentali - intervallo di *benefitParameter* variabile (ampiezza = 0,05)

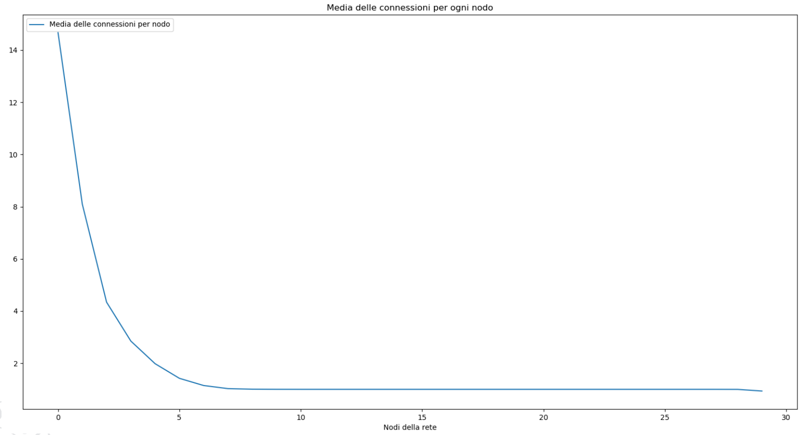




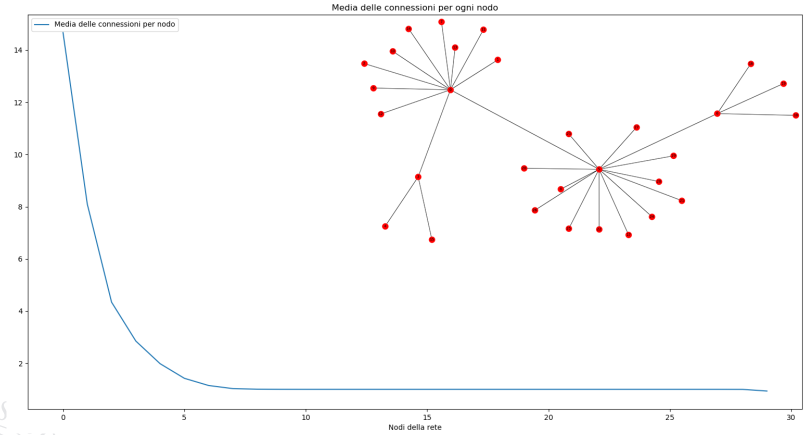
Risultati sperimentali - intervallo di *benefitParameter* variabile (ampiezza = 0,05)



Risultati sperimentali - power-law per reti "Small-World"

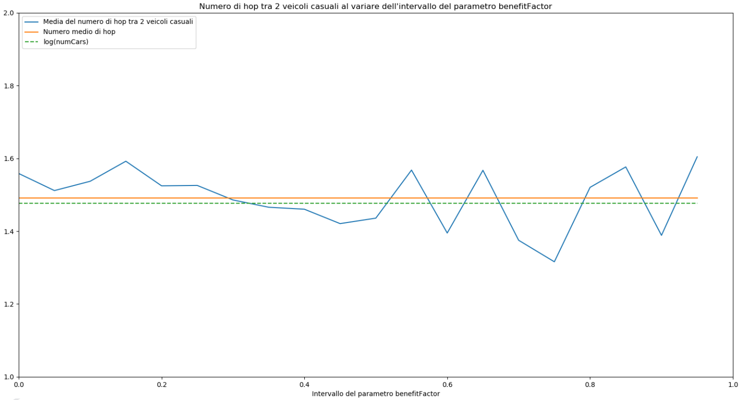


Risultati sperimentali - power-law per reti “Small-World”



Risultati sperimentali - legge Watts-Strogatz per reti "Small-World"

- intervallo di *benefitParameter* variabile



Conclusioni

Obiettivi raggiunti:

- Studio delle VANET e dell'analogia tra batteri e veicoli
- Creazione di un modello protocollare relativo
- Implementazione su framework specializzati

Analisi dei risultati:

- Modello robusto rispetto a variazioni dei parametri
- Power-law verificata
- Scalabilità, data dal modello di Watts-Strogatz, verificata

GRAZIE PER L'ATTENZIONE

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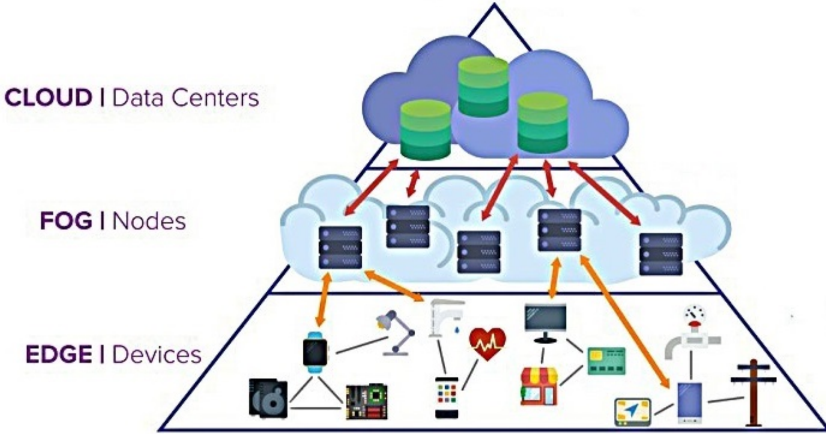
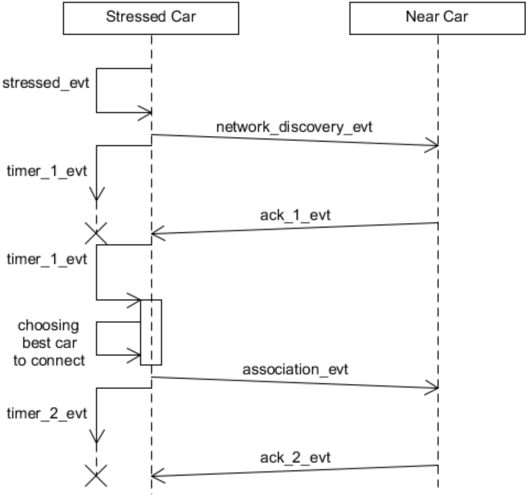
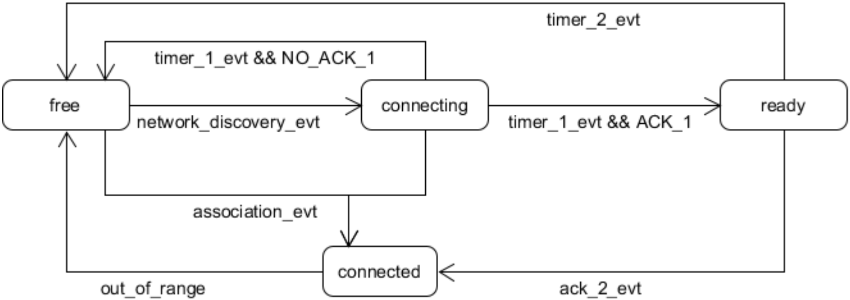
Appendice - FOG COMPUTING



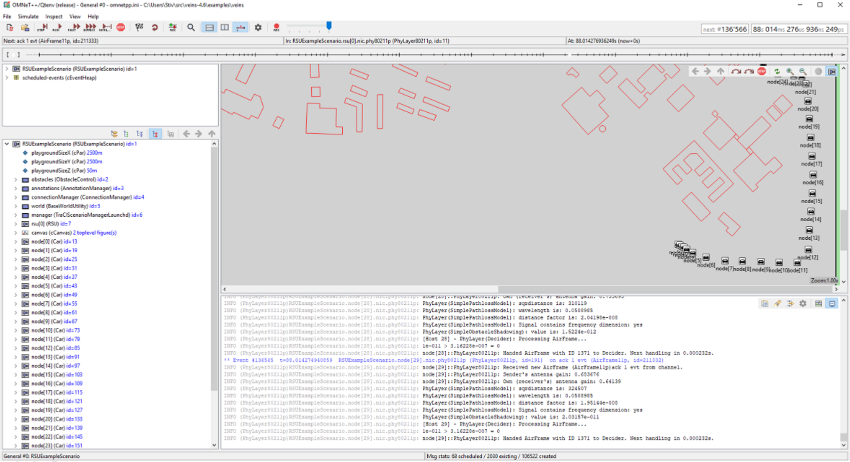
Appendice - SEQUENCE DIAGRAM



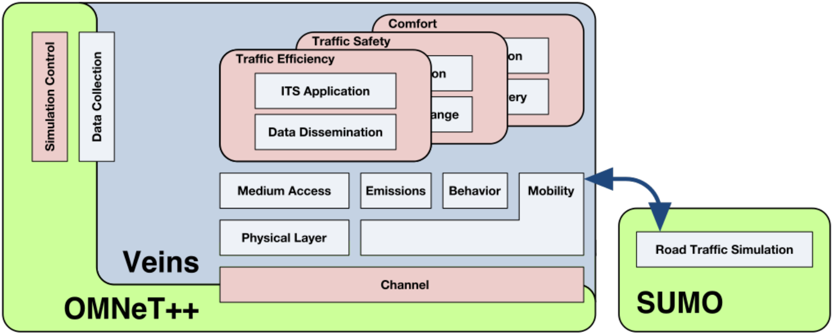
Appendice - FSM



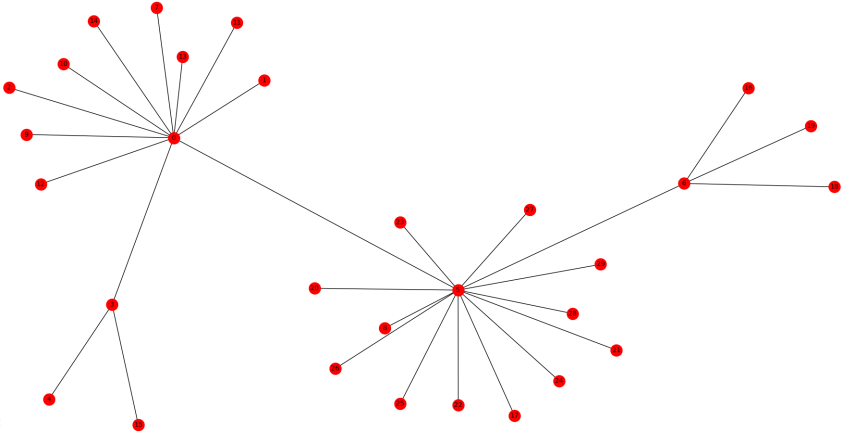
Appendice - SCENARIO OMNET++



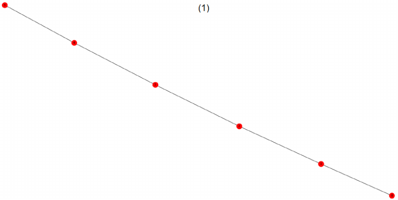
Appendice - VEINS/OMNET++/SUMO

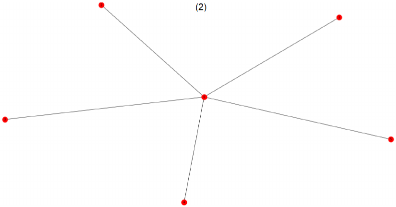


Appendice - ESEMPI DI GRAFO



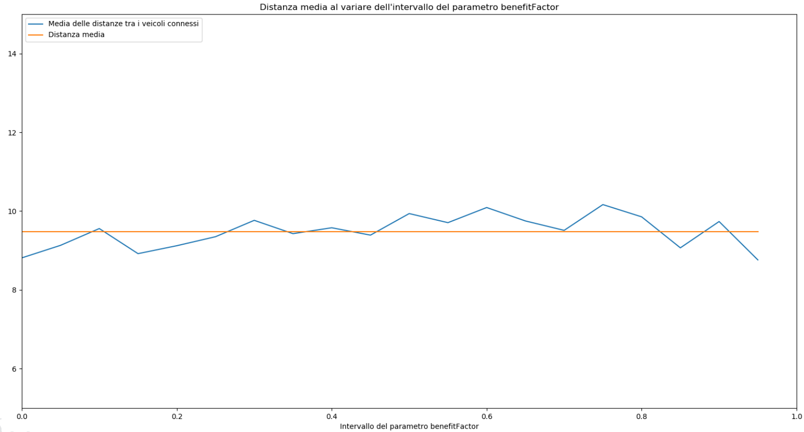
Appendice - ESEMPI DI GRAFO (GRAFI DEGENERI)



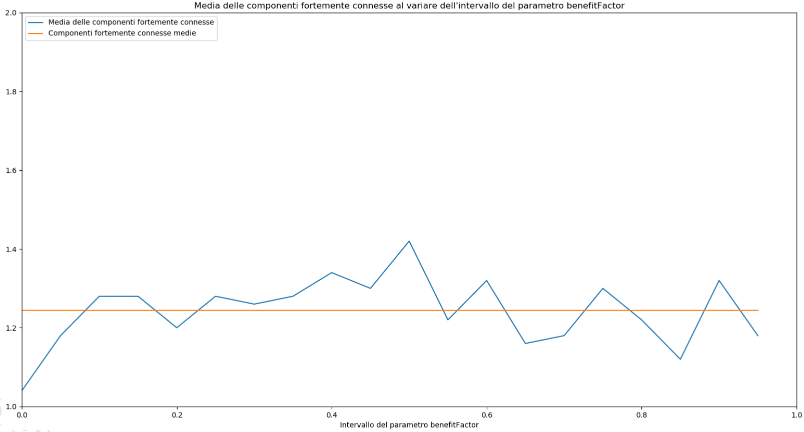


1. Distanza media MINIMA, Branching factor MINIMO, Numero di hop MASSIMO
2. Distanza media MASSIMA, Branching factor MASSIMO, Numero di hop MINIMO

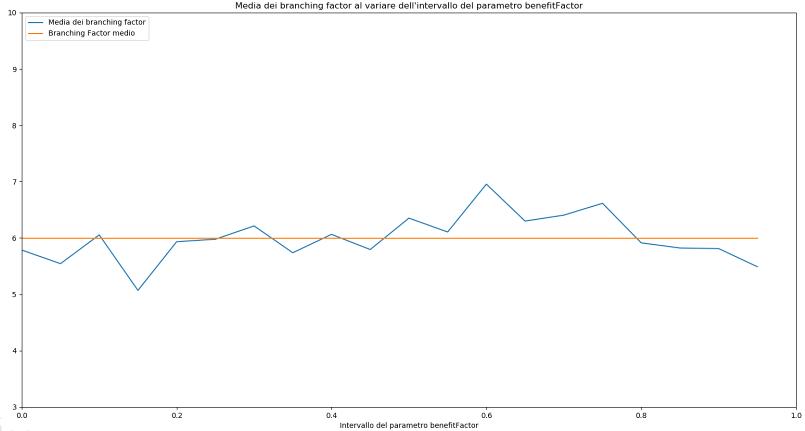
Appendice - MEDIA DELLE DISTANZE



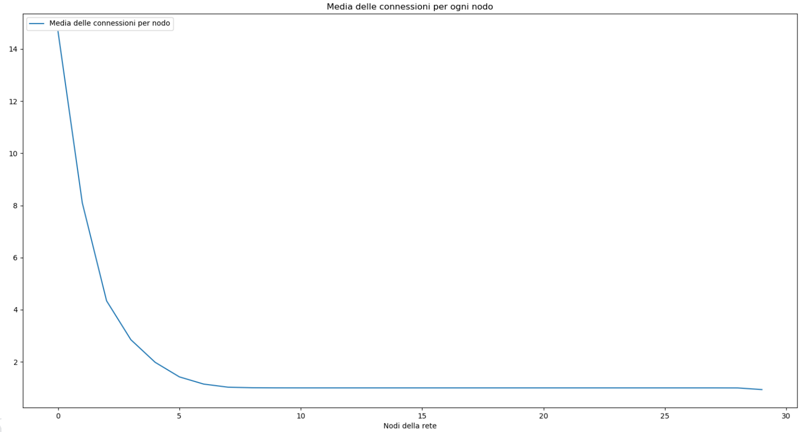
Appendice - MEDIA DELLE COMPONENTI FORTEMENTE CONNESSE



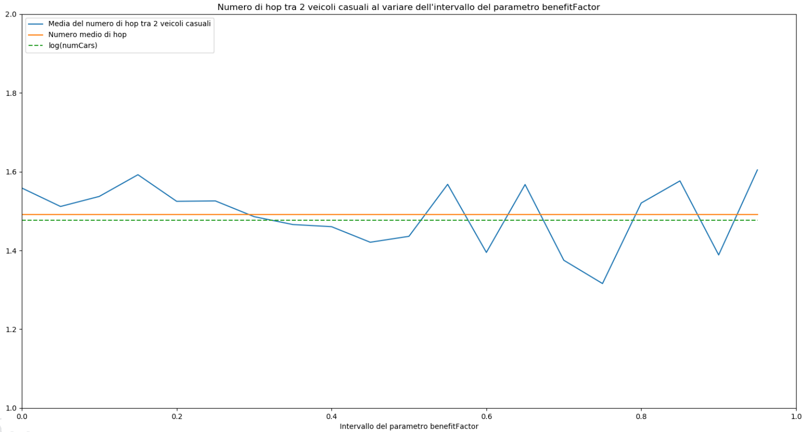
Appendice - MEDIA DEI BRANCHING FACTOR



Appendice - POWER-LAW



Appendice - WATTS-STROGATZ



Appendice - ARTICOLO SU STABILITÁ DELLE MICRO-COLONIE BATTERICHE (1)

- A dynamic network formation model for understanding bacterial self-organization into micro-colonies

Luca Canzian (M'13) received the B.Sc., M.Sc., and Ph.D. degrees in electrical engineering from the University of Padova, Padova, Italy, in 2005, 2007, and 2013, respectively. From 2007 to 2009 he worked in Venice, Italy, as an R&D Engineer at Tecnomare, a company providing design and engineering services for the oil industry. From September 2011 to March 2012 he was on leave at the University of California, Los Angeles (UCLA). From January 2013 to April 2014 he was a PostDoc at the Electrical Engineering Department at UCLA. From April 2014 to April 2015 he was a PostDoc at the Computer Science Department at University of Birmingham, UK. Since April 2015 he has been working in Bassano del Grappa, Italy, as an R&D Engineer at Qascom, a company providing design and engineering services for the satellite communication and navigation industry.

Gerard C. L. Wong received the B.S. and Ph.D. degrees in physics from Caltech and Berkeley, respectively. He is a Professor in the Department of Bioengineering, Department of Chemistry, and the California NanoSystems Institute at UCLA. He joined the Materials Science & Engineering Department and Physics Department at the University of Illinois at Urbana-Champaign in 2000 and moved to UCLA in 2009. His awards include a Beckman Young Investigator Award, an Alfred P Sloan Fellowship, and two Xerox Faculty Research Awards. He is a Fellow of the American Physical Society (2011), and leads a new multidisciplinary center on bacterial biofilms for the Human Frontiers Science Program. In addition to bacterial biofilm biology and ecology, his current research interests include antibiotic design and autoimmune diseases.

Kun Zhao received the Bachelor's degree in physics from Beijing University, Beijing, China, and the Ph.D. degree in condensed matter physics at Princeton University, Princeton, NJ, USA. After receiving his doctorate, he trained as a postdoctoral fellow at the University of California, Los Angeles, where he investigated complex pattern formation in two model systems: anisotropic shaped colloids and biofilms. He recently joined Tianjin University as a Professor in the School of Chemical Engineering and Technology. His current research focuses on self-organization in soft materials including the social behaviors of microbes.

Mihaela van der Schaar (F'10) is Chancellor's Professor of Electrical Engineering at University of California, Los Angeles, CA, USA. She is a Distinguished Lecturer of the Communications Society for 2011–2012 and the Editor-in-Chief of IEEE TRANSACTIONS ON MULTIMEDIA (2011–2013). She received an NSF CAREER Award (2004), the Best Paper Award from IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY (2005), the Okawa Foundation Award (2006), the IBM Faculty Award (2005, 2007, and 2008), the Most Cited Paper Award from EURASIP: Image Communications Journal (2006), the Gamenets Conference Best Paper Award (2011) and the 2011 IEEE Circuits and Systems Society Darlington Award Best Paper Award. She holds 33 granted US patents. She is also the founding director of the UCLA Center for Engineering Economics, Learning, and Networks (see http://netecon.ee.ucla.edu). For more information about her research visit: http://medianetlab.ee.ucla.edu/

Appendice - ARTICOLO SU STABILITÁ DELLE MICRO-COLONIE BATTERICHE (2)

- A dynamic network formation model for understanding bacterial self-organization into micro-colonies