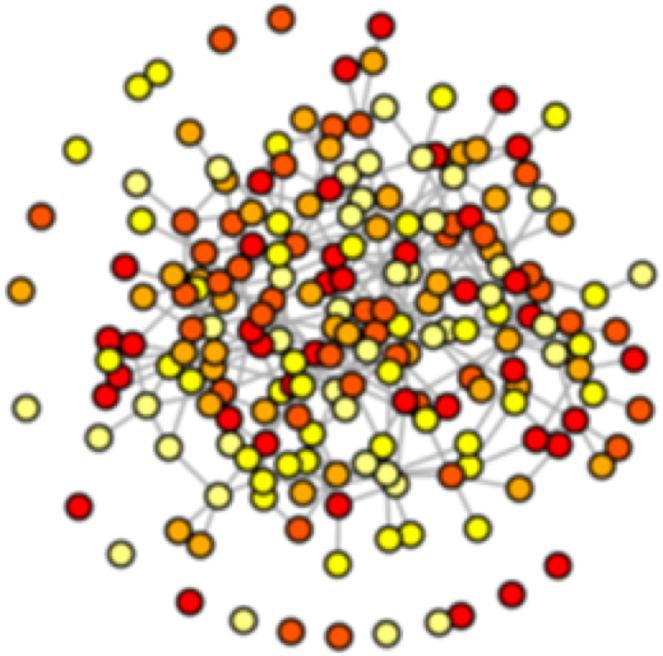

Introduction to Networks

Robin A. Choudhury

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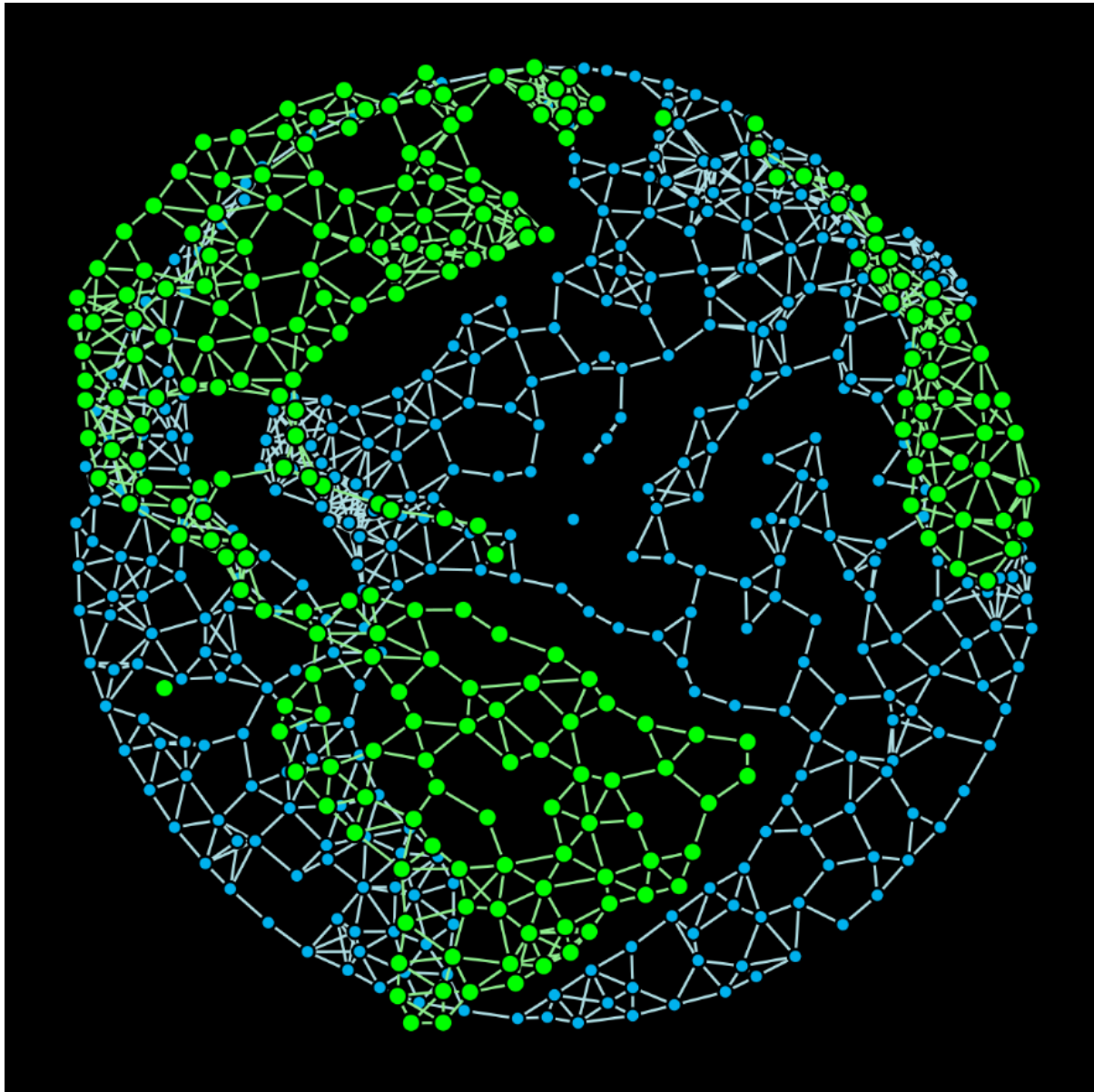
PLANT PATHOLOGY
UF/IFAS

UF IFAS
UNIVERSITY of FLORIDA

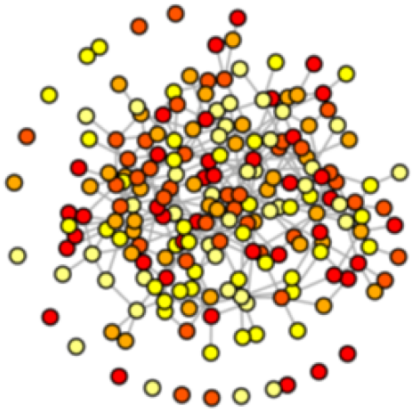
Institute for
Sustainable Food
Systems

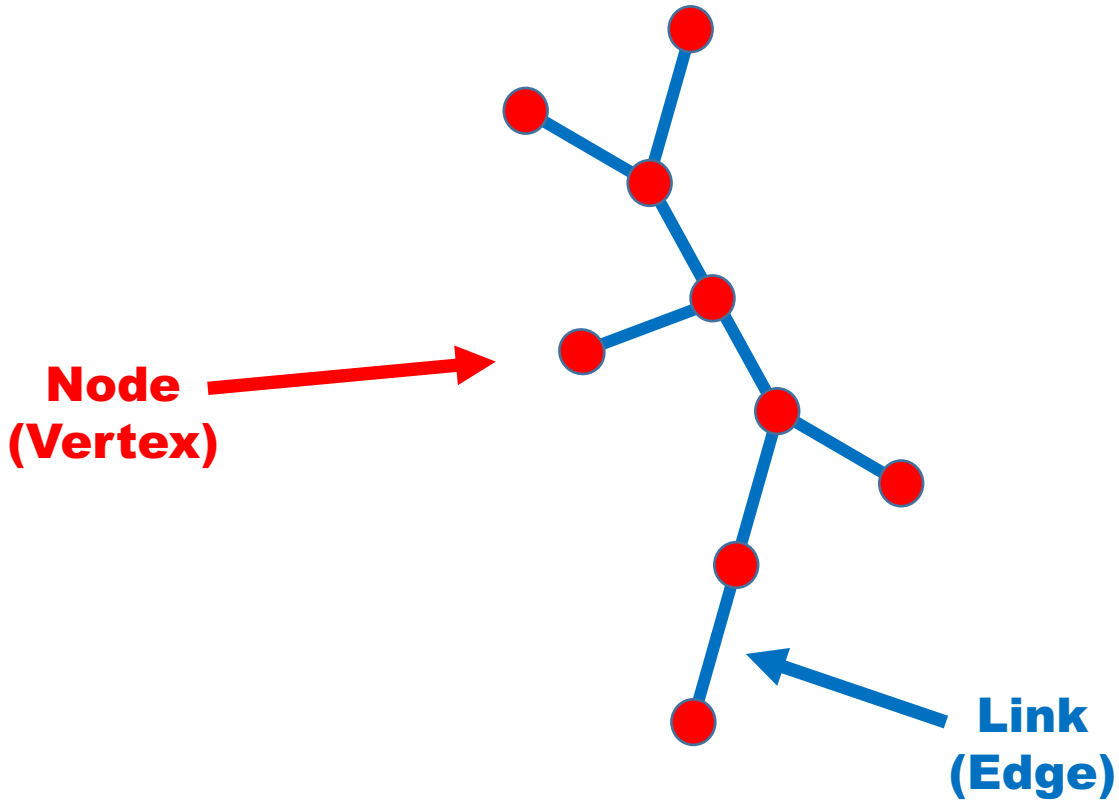
Learning Goals

- Understand some general concepts related to network analysis, with applications in…
- Epidemics
- Crop Breeding
- Trade
- Microbiomes
- And more

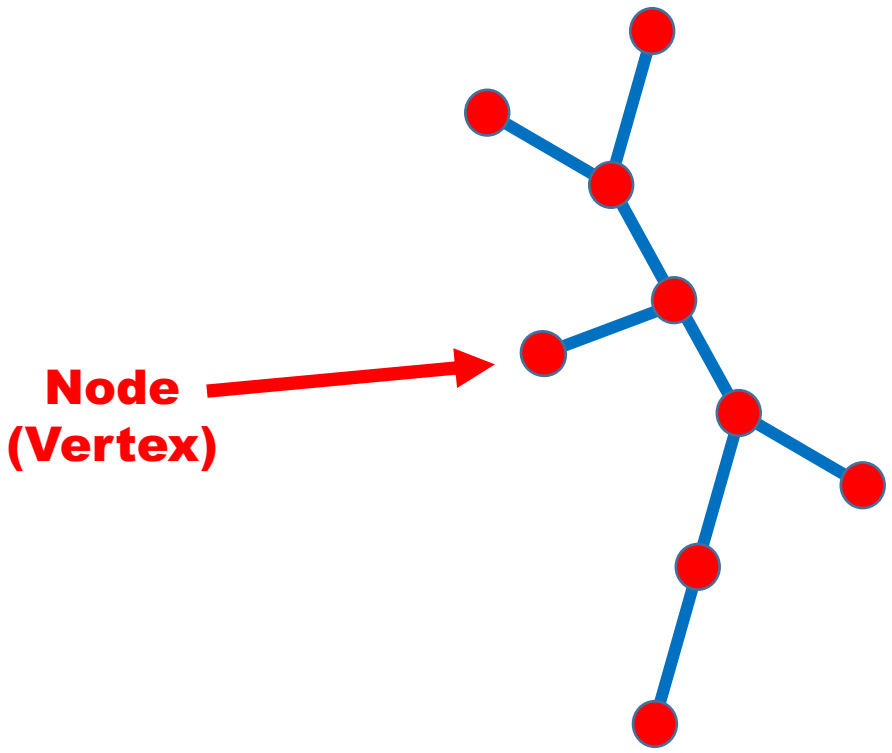


Pieces of a Network



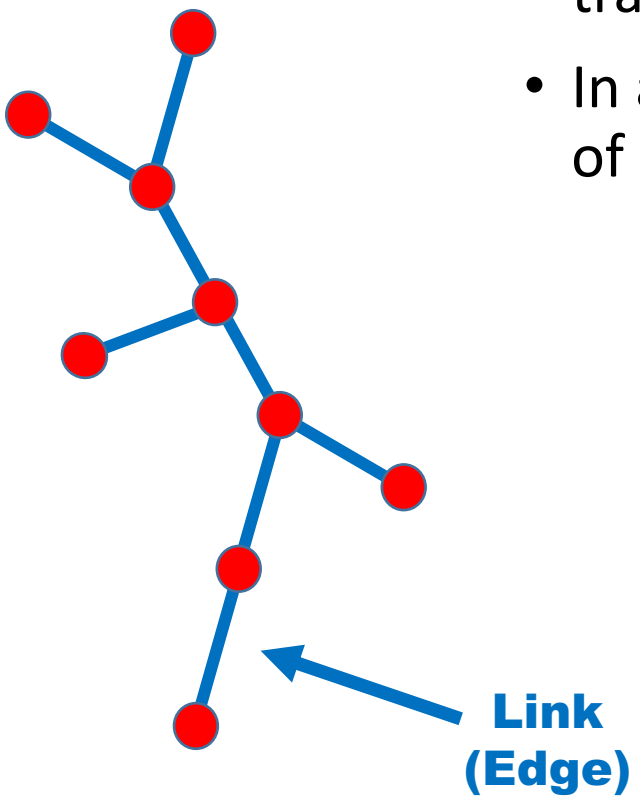


Traits of Network Nodes



- In a socioeconomic network, nodes are people or human institutions (managers/farmers, extension agents, scientists, …)
- In a biophysical network, nodes are geographic locations (individual plants, farms, storage facilities, wildlands, …)

Traits of Network Links

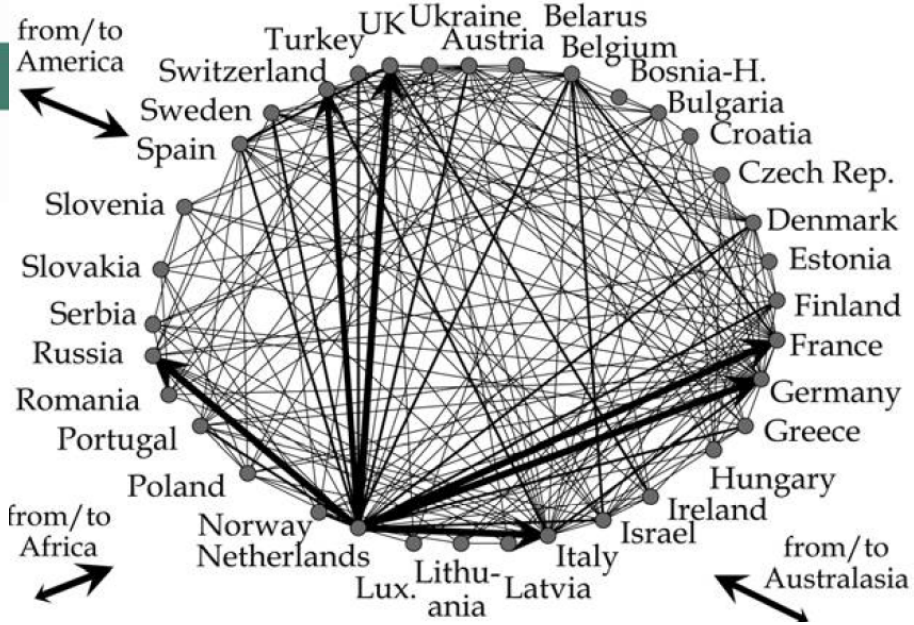


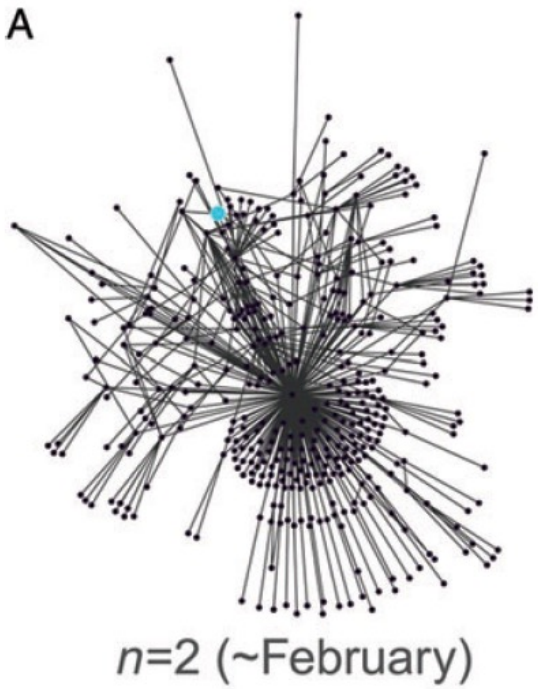
- In a socioeconomic network, links are transmission of information, goods, or money.
- In a biophysical network, links are transmission of inoculum, infested seed material, and vectors.

Phytopathology
REVIEW

Networks in Plant Epidemiology: From Genes to Landscapes, Countries, and Continents

Mathieu Moslonka-Lefebvre, Ann Finley, Ilaria Dorigatti, Katharina Dehnen-Schmutz, Tom Harwood, Michael J. Jeger, Xiangming Xu, Ottmar Holdenrieder, and Marco Pautasso





AoB PLANTS
The open-access journal for plant sciences

Review

Network epidemiology and plant trade networks

Marco Pautasso[1]* and Mike J. Jeger[2]

Connectivity of the American Agricultural Landscape: Assessing the National Risk of Crop Pest and Disease Spread

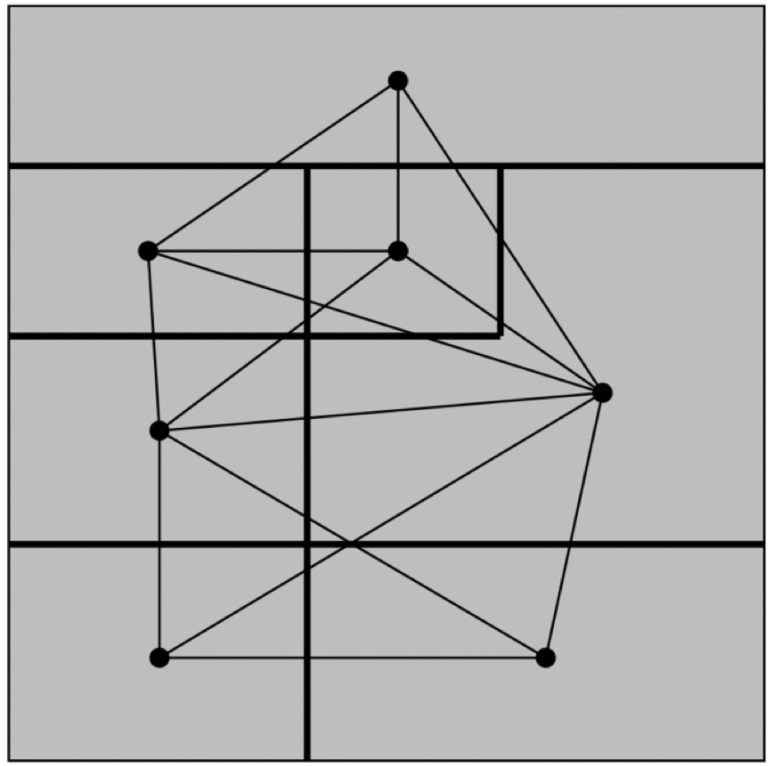
MARGARET L. MARGOSIAN, KAREN A. GARRETT, J. M. SHAWN HUTCHINSON, AND KIMBERLY A. WITH

February 2009 / Vol. 59 No. 2 • BioScience 141

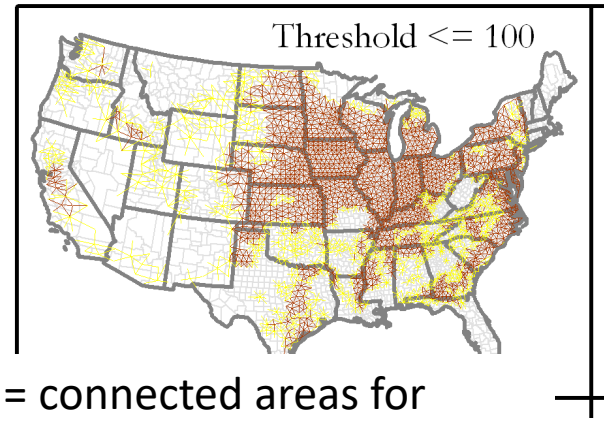
Peg Margosian

Nodes: US counties

Links: measures of likelihood of pathogen movement based on host abundance



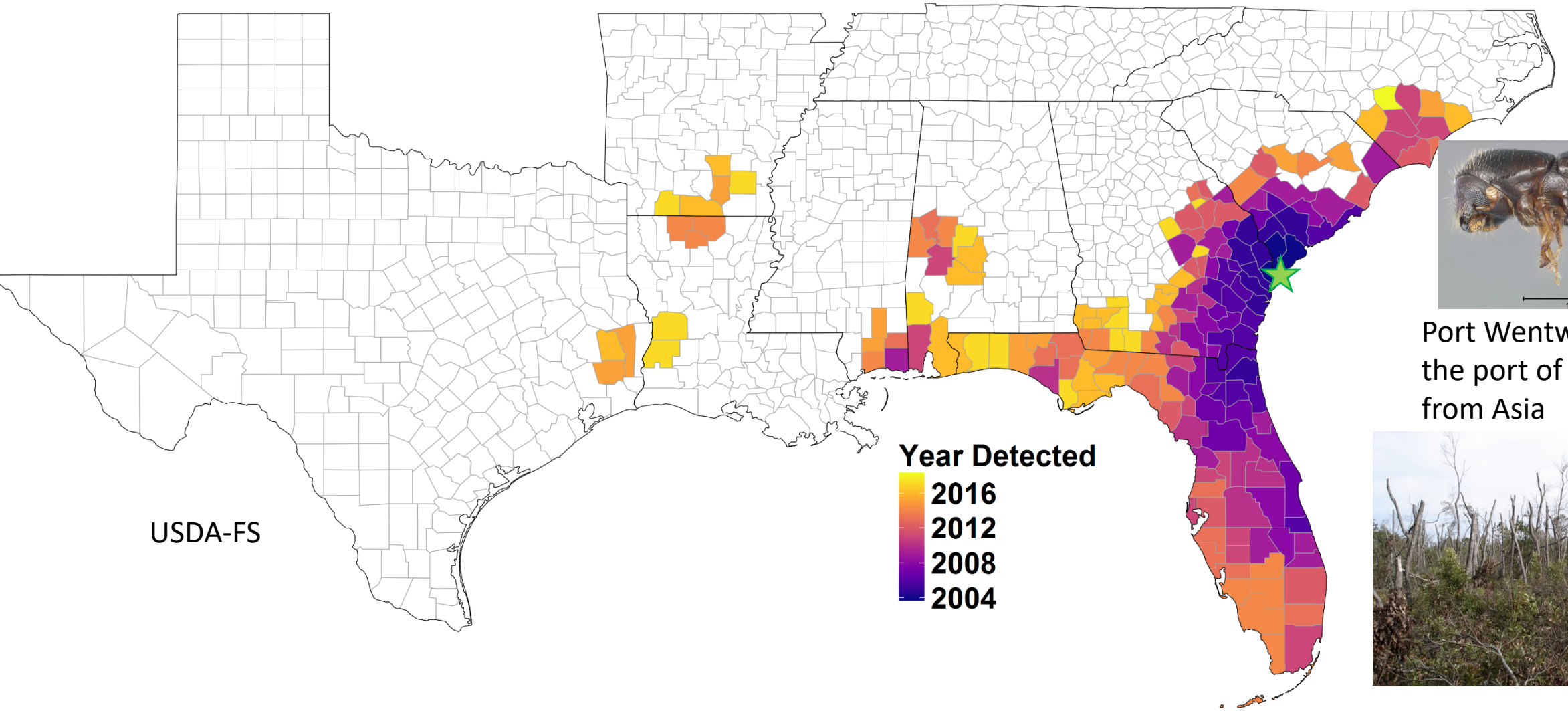
Maize



Red = connected areas for pathogens that require **at least low** maize density to spread

Red = connected areas for pathogens that require **high** maize density to spread

Laurel Wilt Disease



USDA-FS

2002

Port Wentworth near the port of Savannah from Asia

2004

Epidemic network analysis for mitigation of invasive pathogens in seed systems: Potato in Ecuador

Phytopathology 2017

C. E. Buddenhagen*, J. F. Hernandez Nopsa*, K. F. Andersen, J. Andrade-Piedra, G. A. Forbes, P. Kromann, S. Thomas-Sharma, P. Useche, K. A. Garrett

CGIAR RESEARCH PROGRAM ON Roots, Tubers and Bananas

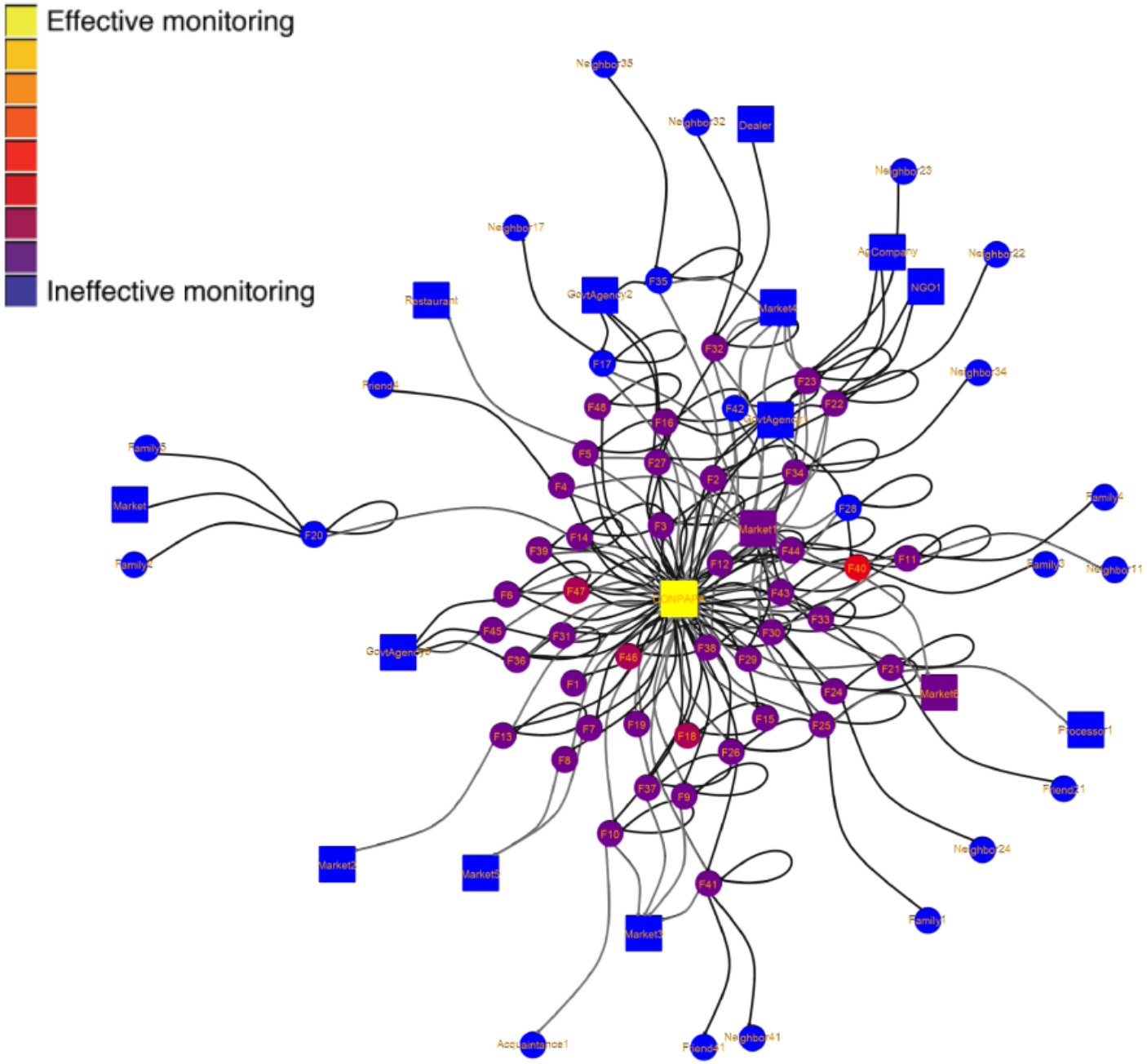
CENTRO INTERNACIONAL DE LA PAPA CIP

UF IFAS UNIVERSITY of FLORIDA

Potato production in Tungurahua Province, Ecuador

Photos: J Hernandez Nopsa

In this analysis, we have survey data for both potato transactions and sources of information for IPM



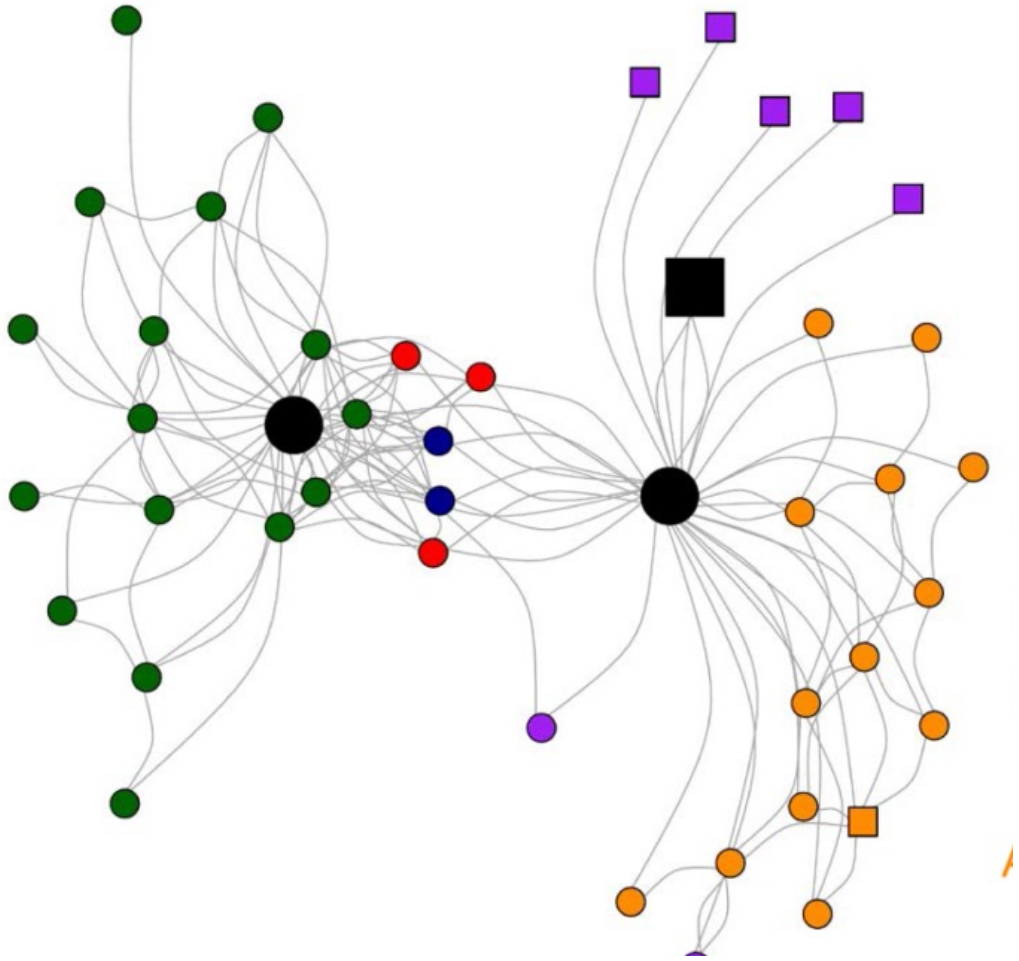
Scenario analysis indicating how effective monitoring of the spread of a pathogen would be at each node, based on location in network and IPM information sources

Buddenhagen, Hernandez Nopsa, et al. 2017

Resistance Genes in Global Crop Breeding Networks

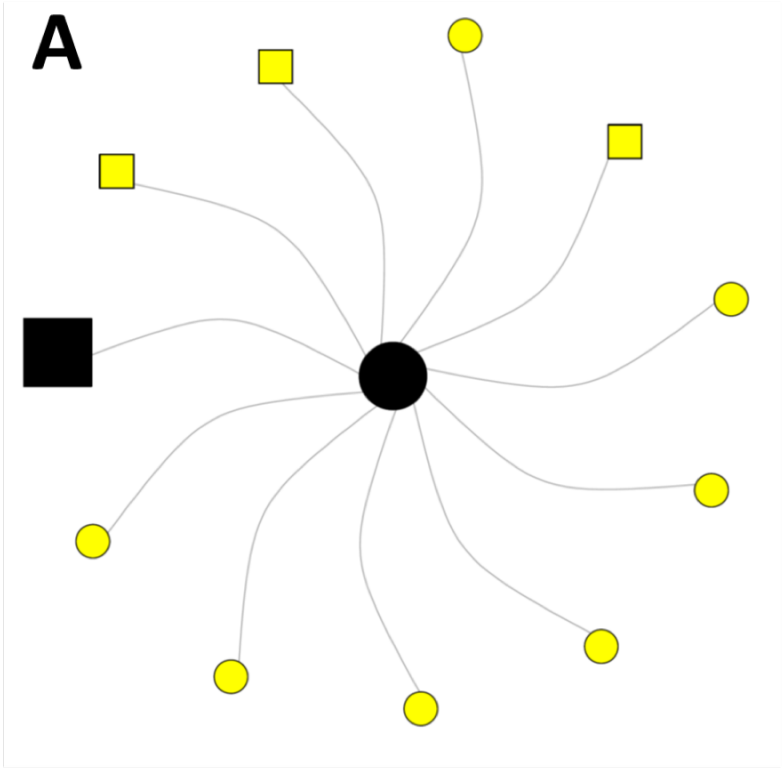
K. A. Garrett,† K. F. Andersen, E. Asche, R. L. Bowden, G. A. Forbes, P. A. Kulakow, and B. Zhou

Phytopathology 2017



Cassava breeding network

Three potential scenarios for crop breeding networks



- Public
- Private

Black: International

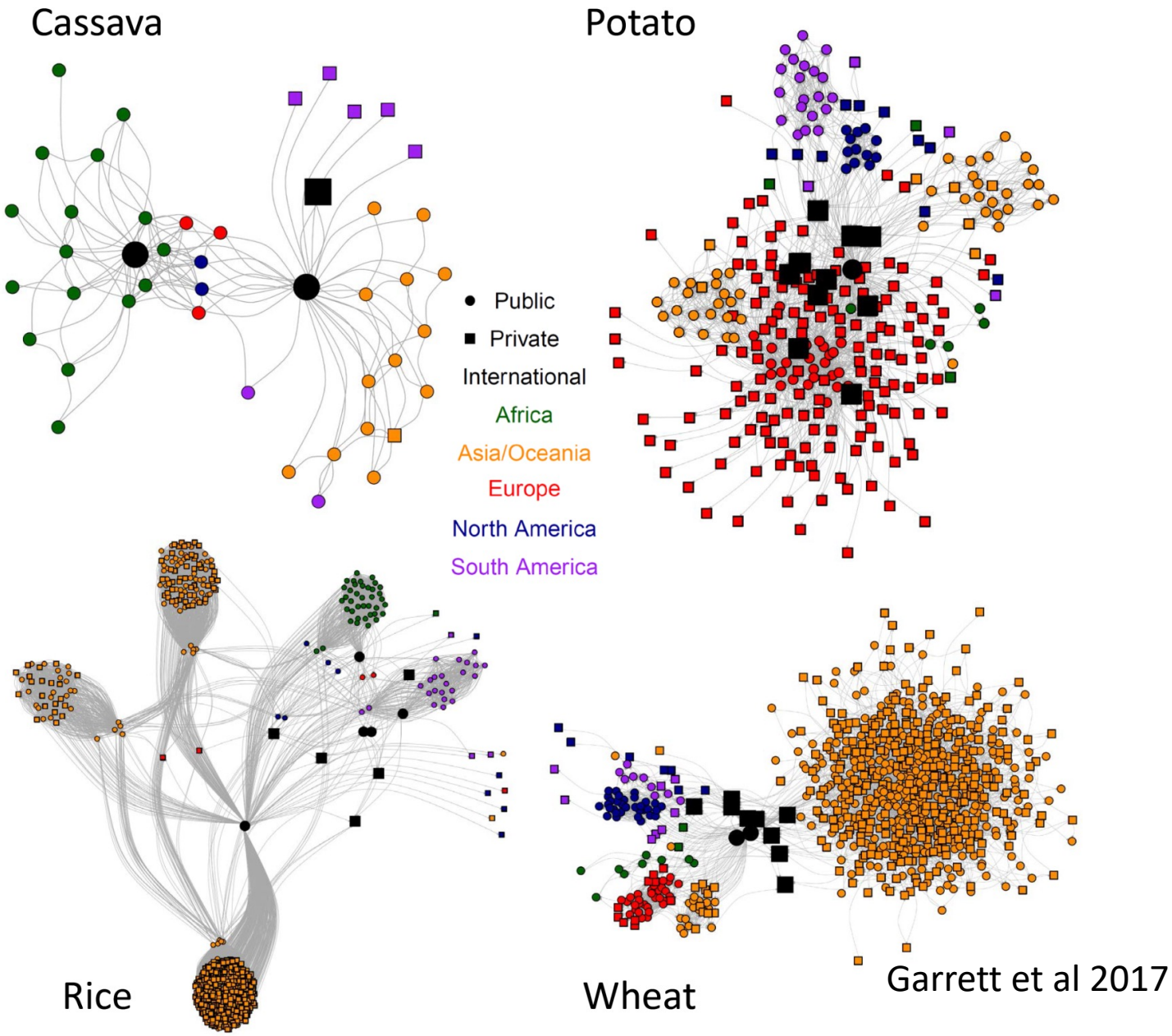
Yellow:Regional

International public breeding group is central hub and bridge node between regional groups

International public breeding group is central hub, but with connections between regional groups

Fragmentation of the network without a central international public breeding group

Can global crop breeding networks adapt to new disease challenges under global change?

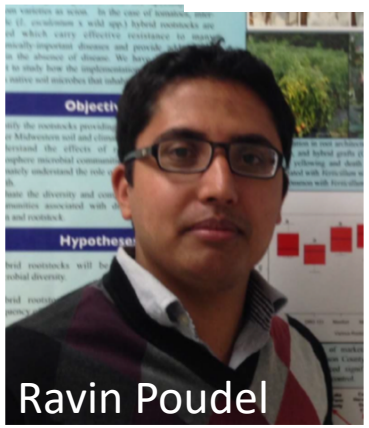


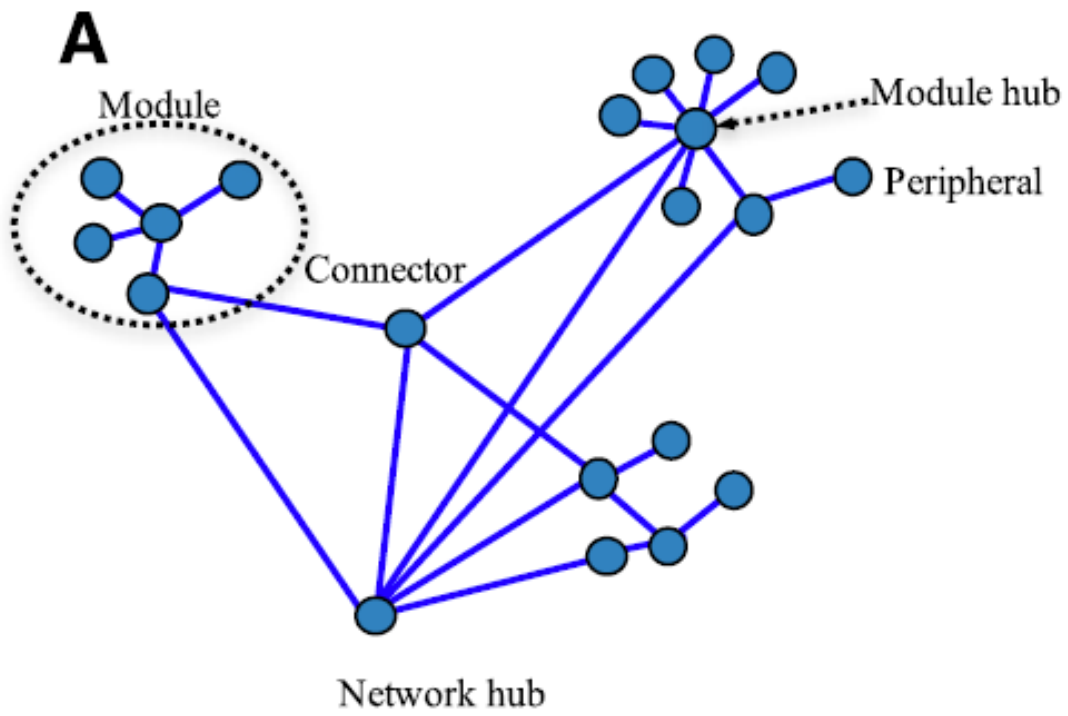
Garrett et al 2017

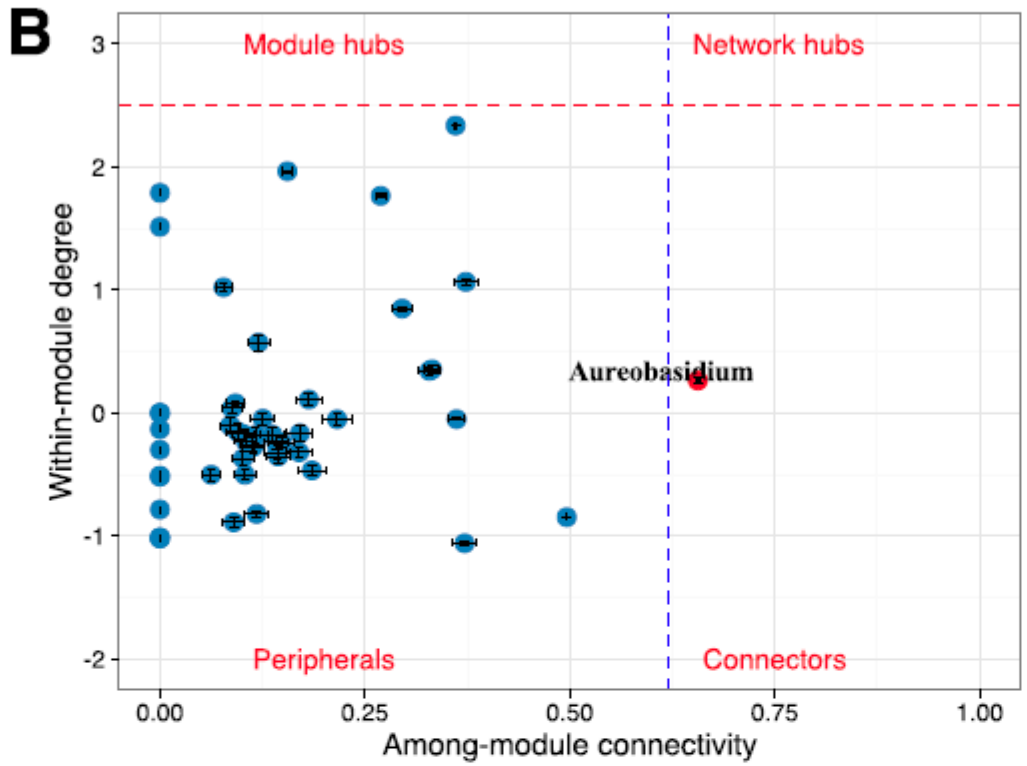
Microbiome Networks: A Systems Framework for Identifying Candidate Microbial Assemblages for Disease Management

R. Poudel, A. Jumpponen, D. C. Schlatter, T. C. Paulitz, B. B. McSpadden Gardener, L. L. Kinkel, and K. A. Garrett

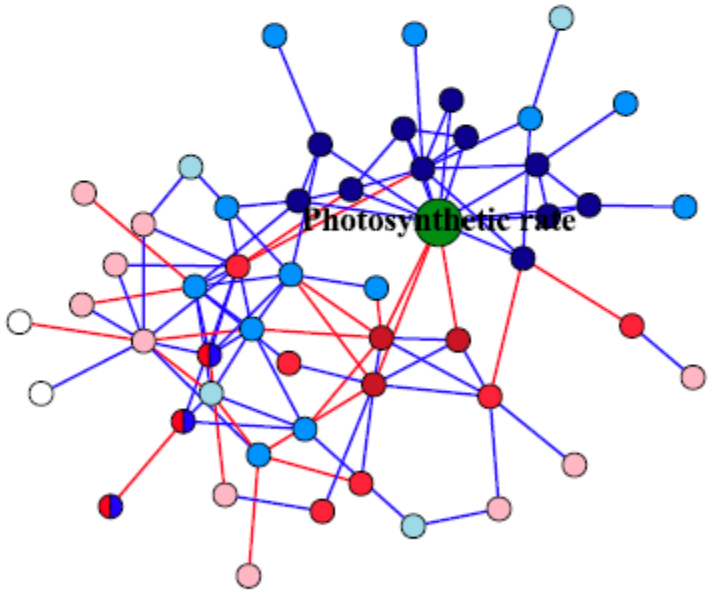
Phytopathology 2016



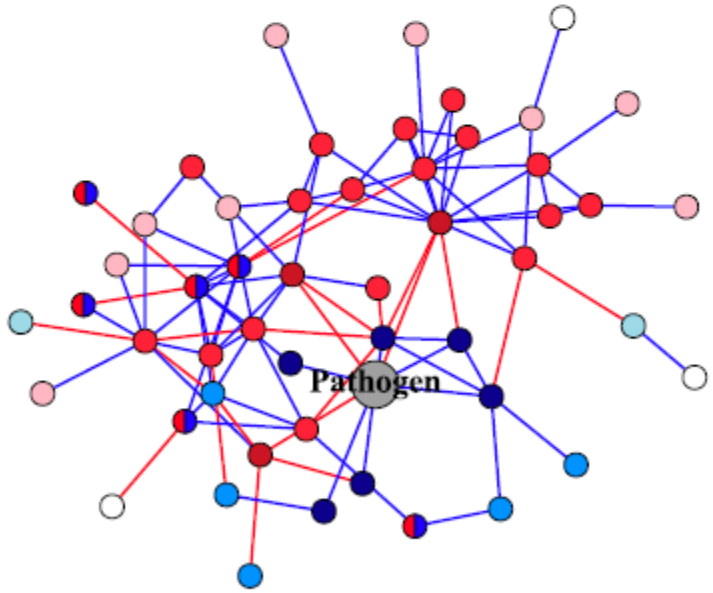




How do pathogen and host variables affect the microbiomes of plants?

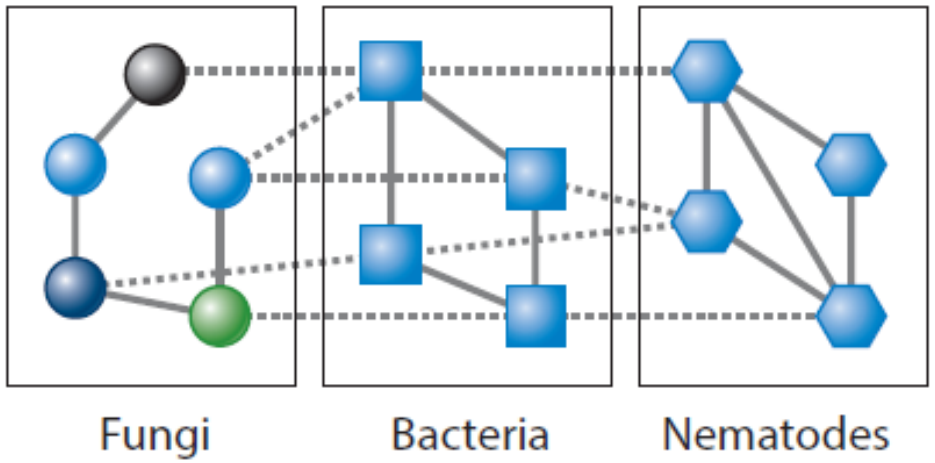


host variables



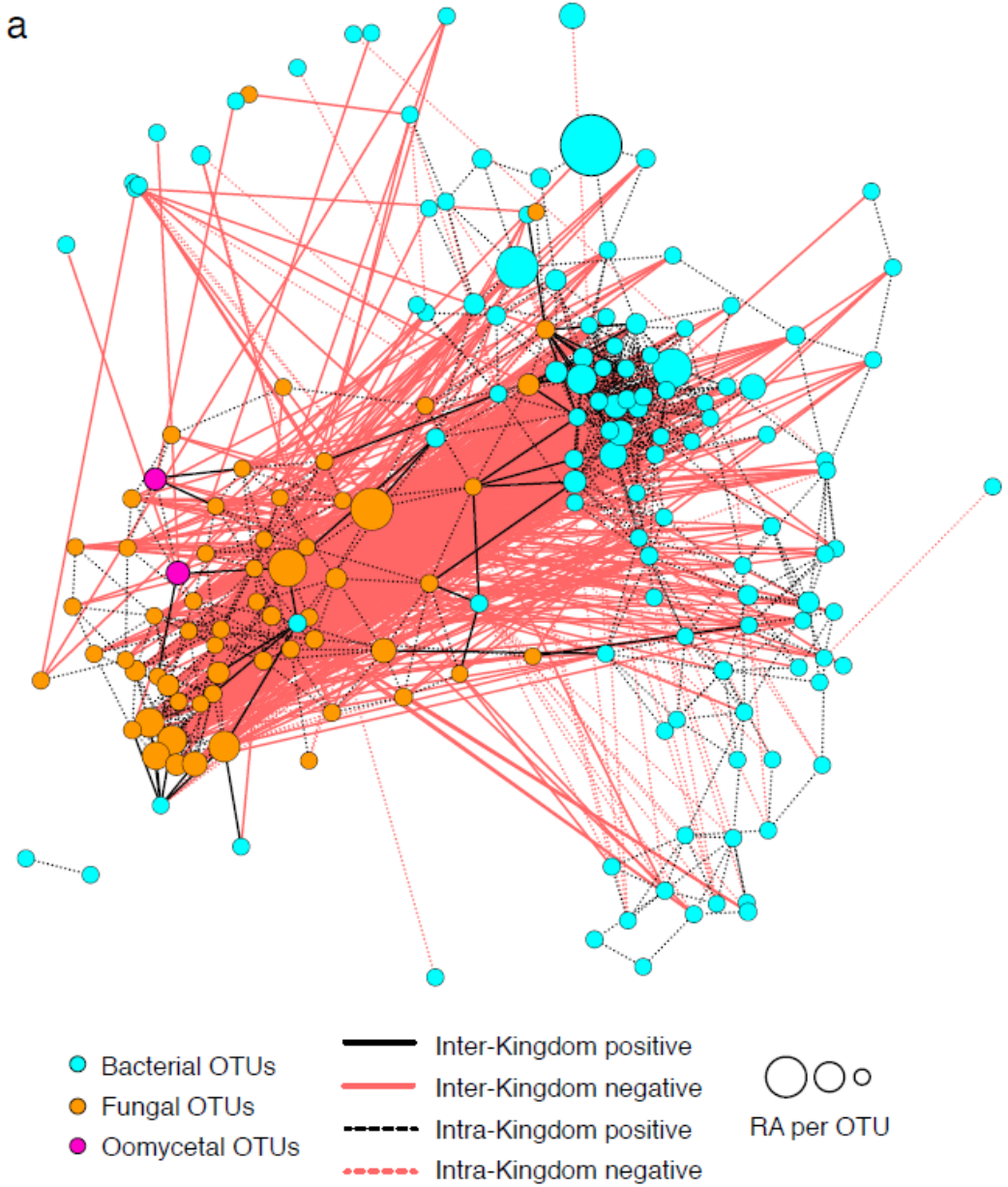
pathogen variables

How do microbes interact both within and between kingdoms?



Microbial interkingdom interactions in roots promote Arabidopsis survival

Paloma Durán[1,5], Thorsten Thiergart[1,5], Ruben Garrido-Oter[1,2], Matthew Agler[1,3], Eric Kemen[1,2,4], Paul Schulze-Lefert[1,2,6,*], Stéphane Hacquard[1,6,*].

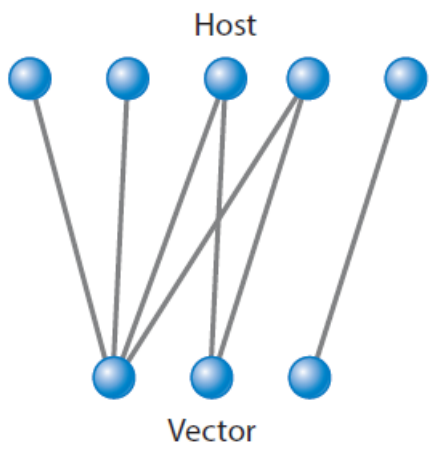


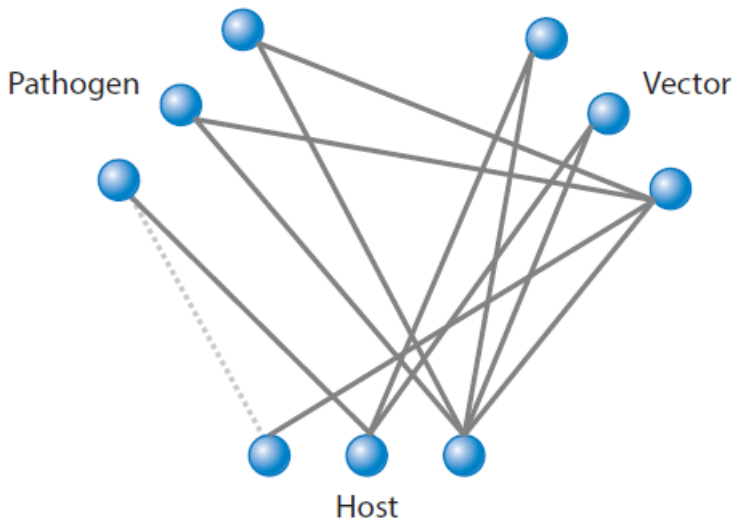
Annual Review of Phytopathology

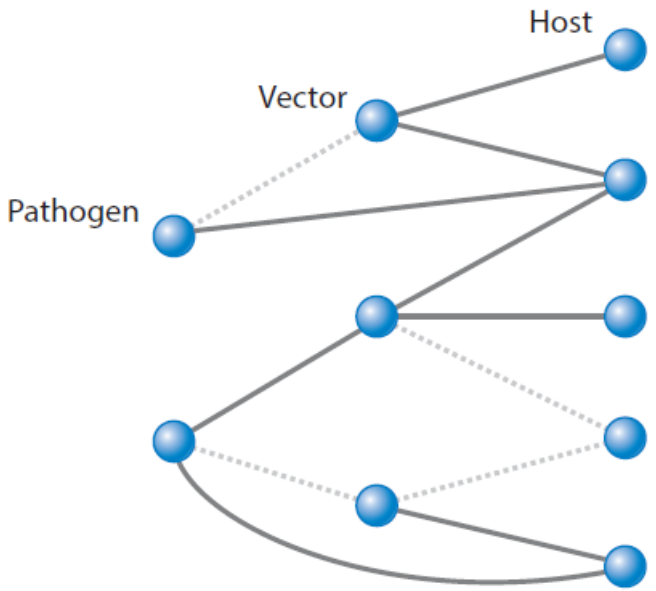
Network Analysis: A Systems Framework to Address Grand Challenges in Plant Pathology

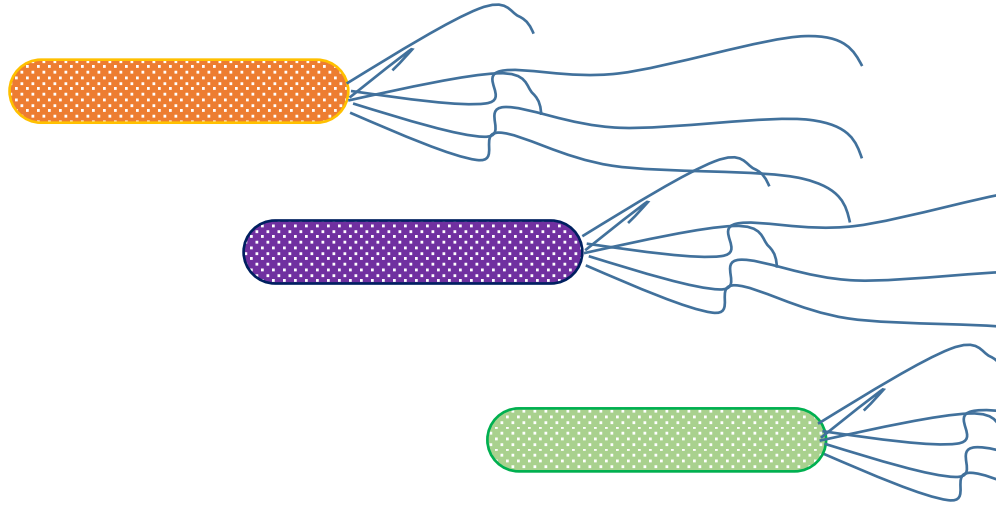
K.A. Garrett,[1,2,3] R.I. Alcalá-Briseño,[1,2,3]
K.F. Andersen,[1,2,3] C.E. Buddenhagen,[1,2,3,4]
R.A. Choudhury,[1,2,3] J.C. Fulton,[1,2,3]
J.F. Hernandez Nopsa,[1,2,3,5] R. Poudel,[1,2,3] and Y. Xing

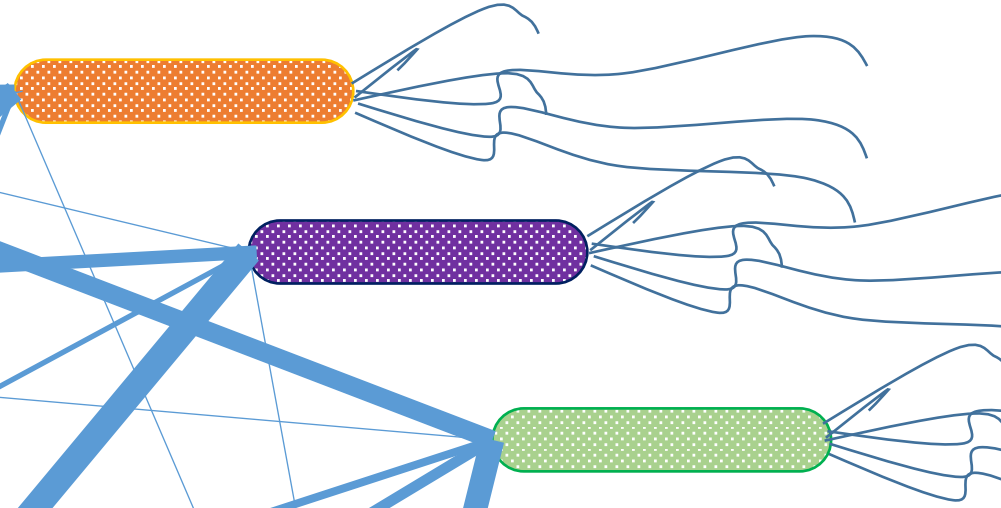
Disease Emergence and Tripartite Networks of Phytobiome Interactions









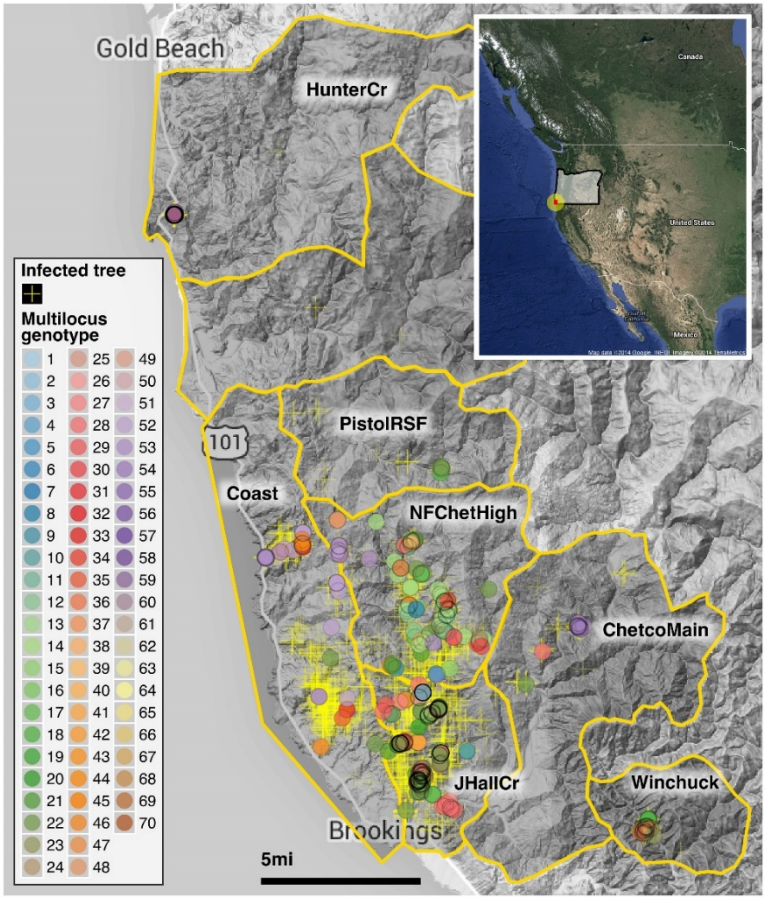


Spatial and Temporal Analysis of Populations of the Sudden Oak Death Pathogen in Oregon Forests

Z. N. Kamvar, M. M. Larsen, A. M. Kanaskie, E. M. Hansen, and N. J. Grünwald

POPPR

Population Genetics in R



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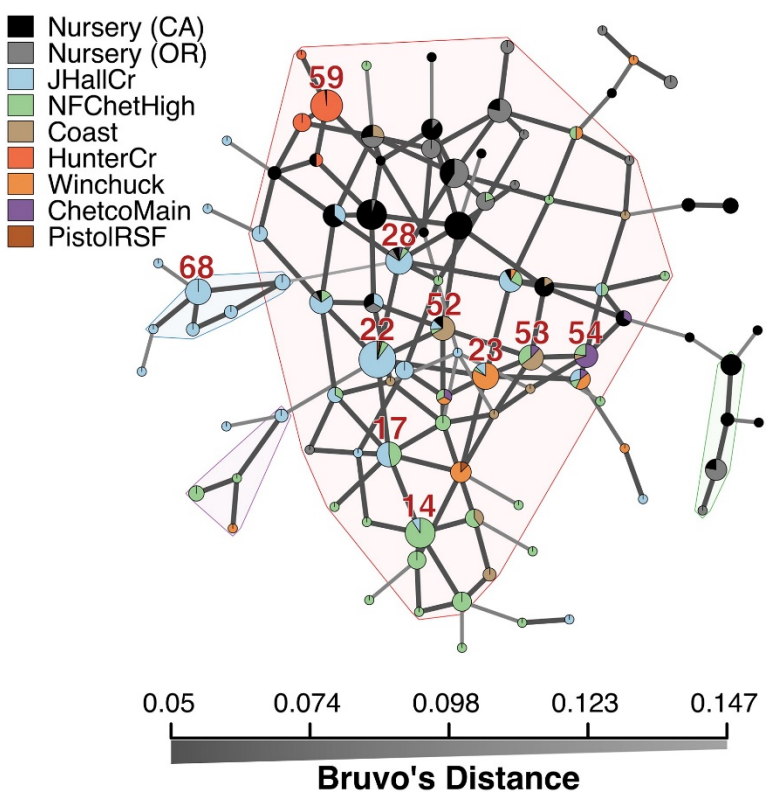
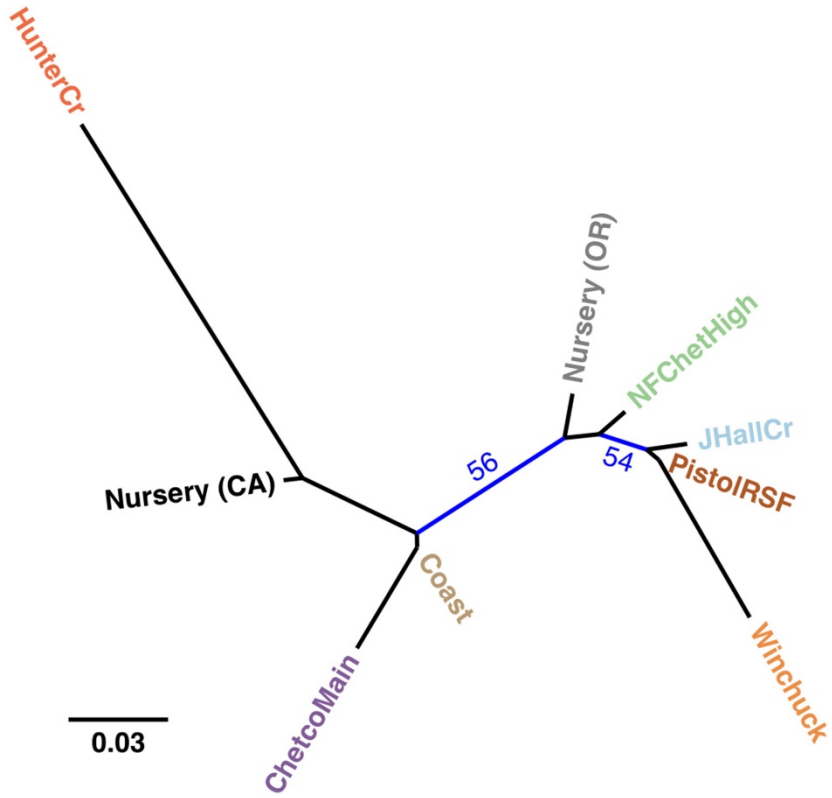
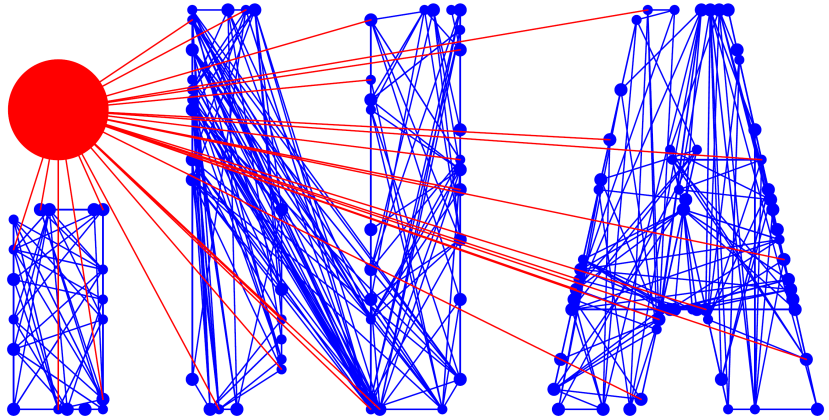




A common problem in pest or disease management

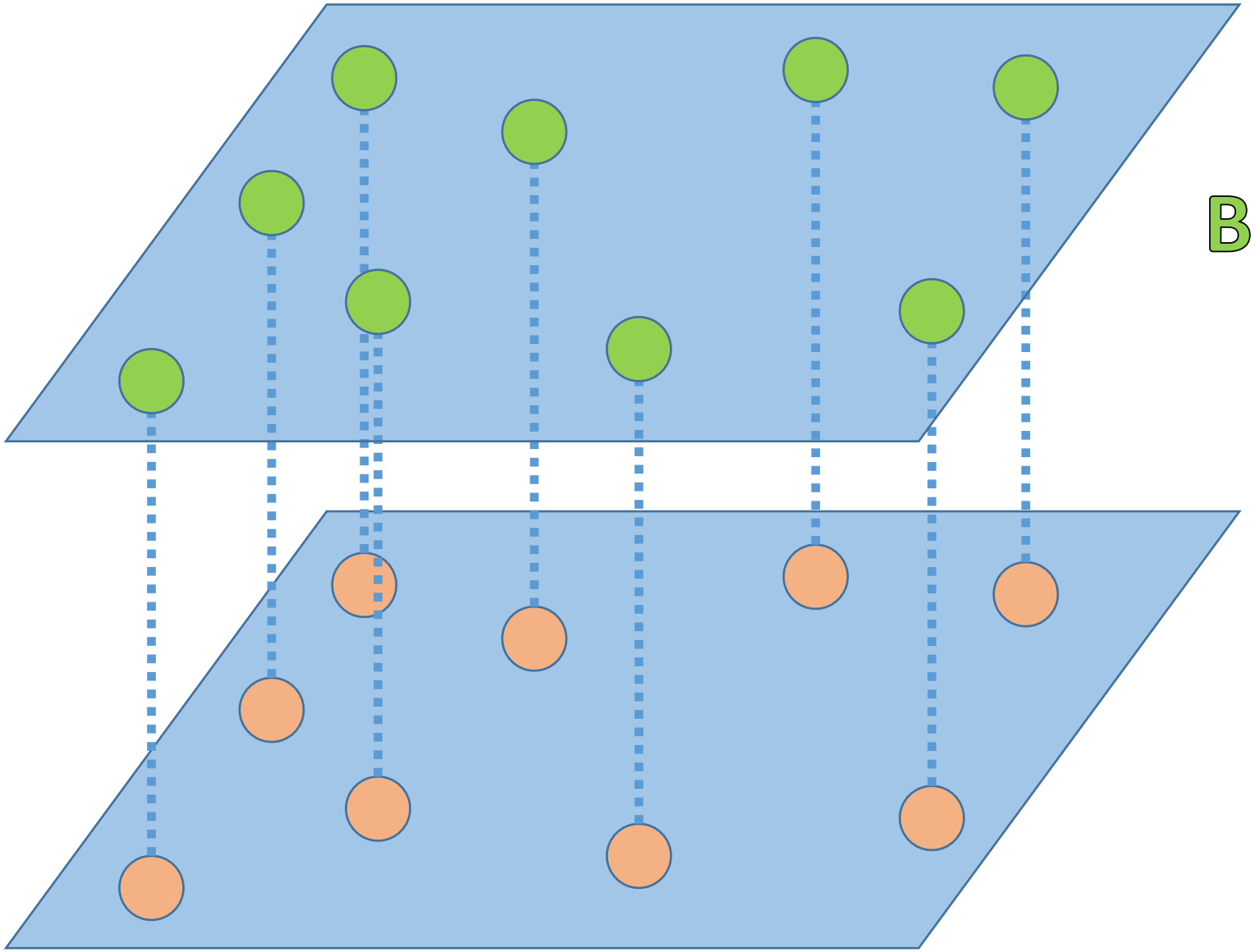
- A management concept or technology may work well in an experiment, but…
  - How well do we really understand its performance across a region?
  - Will a critical mass of people learn about it and adopt it?
  - Will the "management landscape" slow invasions enough to protect production?
- And suppose climate change or a new pest type alter the system dynamics…?
- System analysis can address this problem by identifying priorities for successful regional management

Impact network analysis (INA)



- The Garrett Lab is developing INA as a platform for evaluating system management strategies (such as crop breeding networks, seed systems, and integrated pest and disease management)
- Impact **OF** research products such as information/training, disease resistance, and disease-free seed production technologies
- Impact **ON** spatial ecological processes, such as gene/genotype spread, pathogen invasions or ecosystem services more broadly
- Impact **THROUGH** communication and decision-making networks, and linked biophysical networks

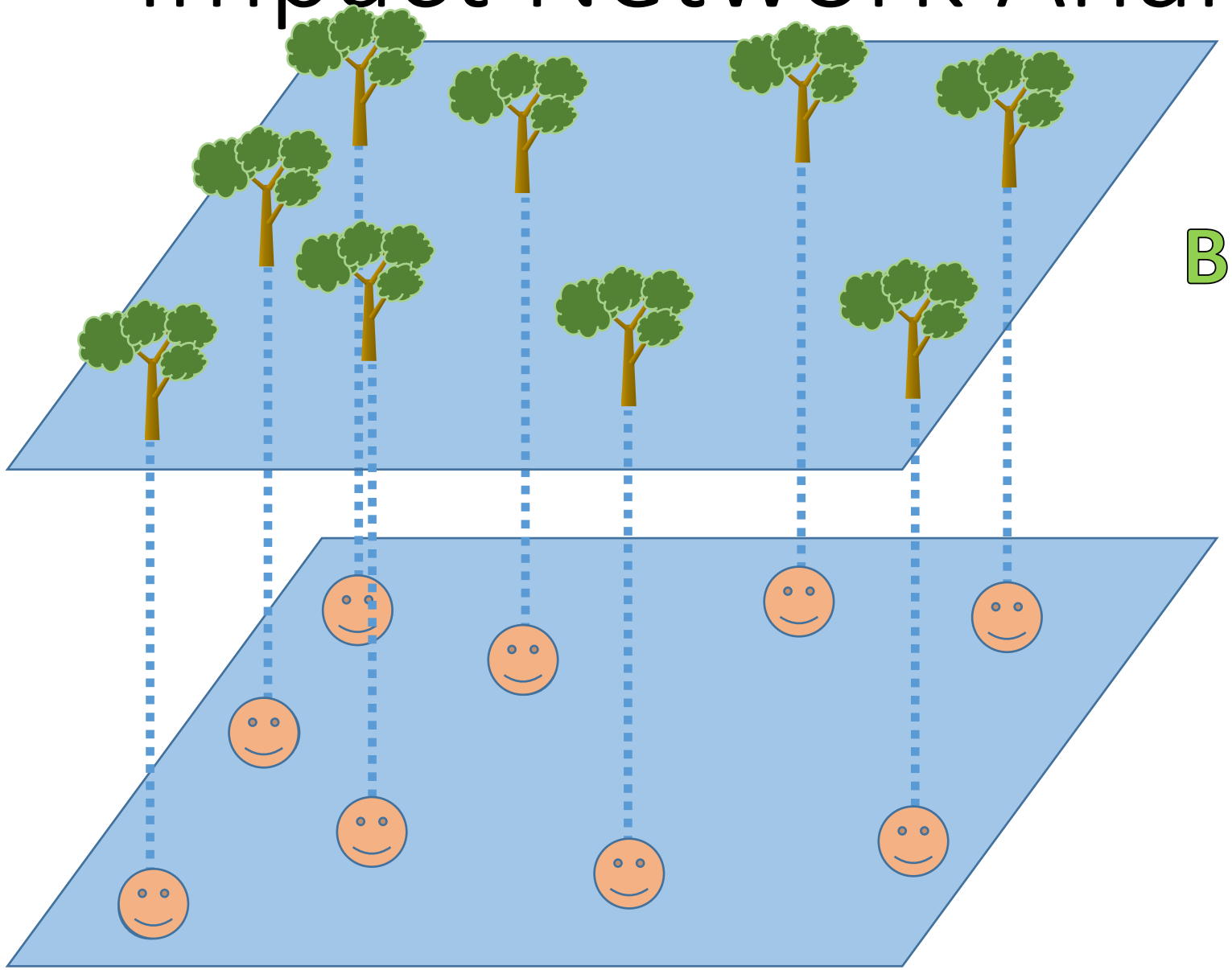
Impact Network Analysis



Biophysical Network

Social Network

Impact Network Analysis



Biophysical Network

Social Network

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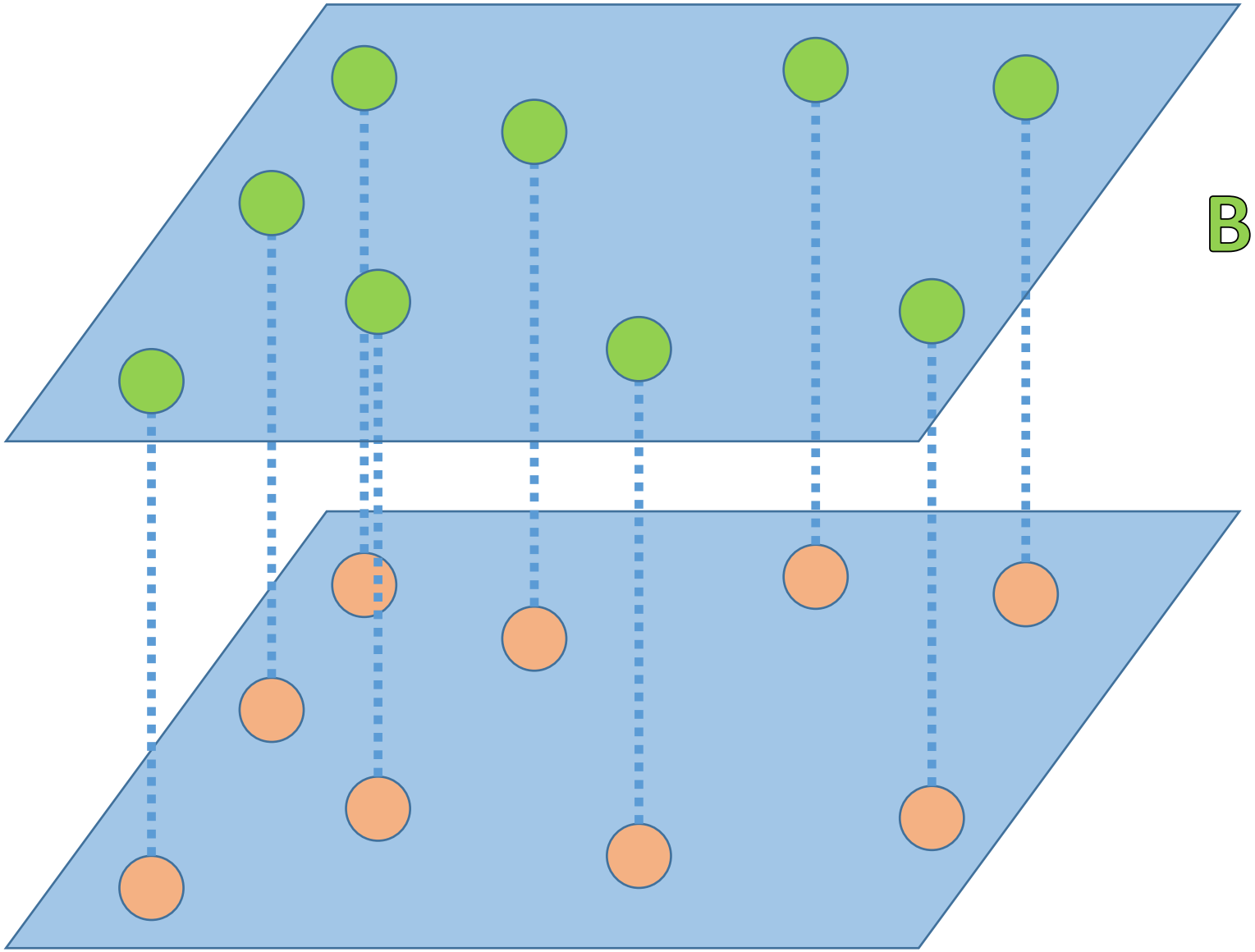

Biophysical Network

Social Network

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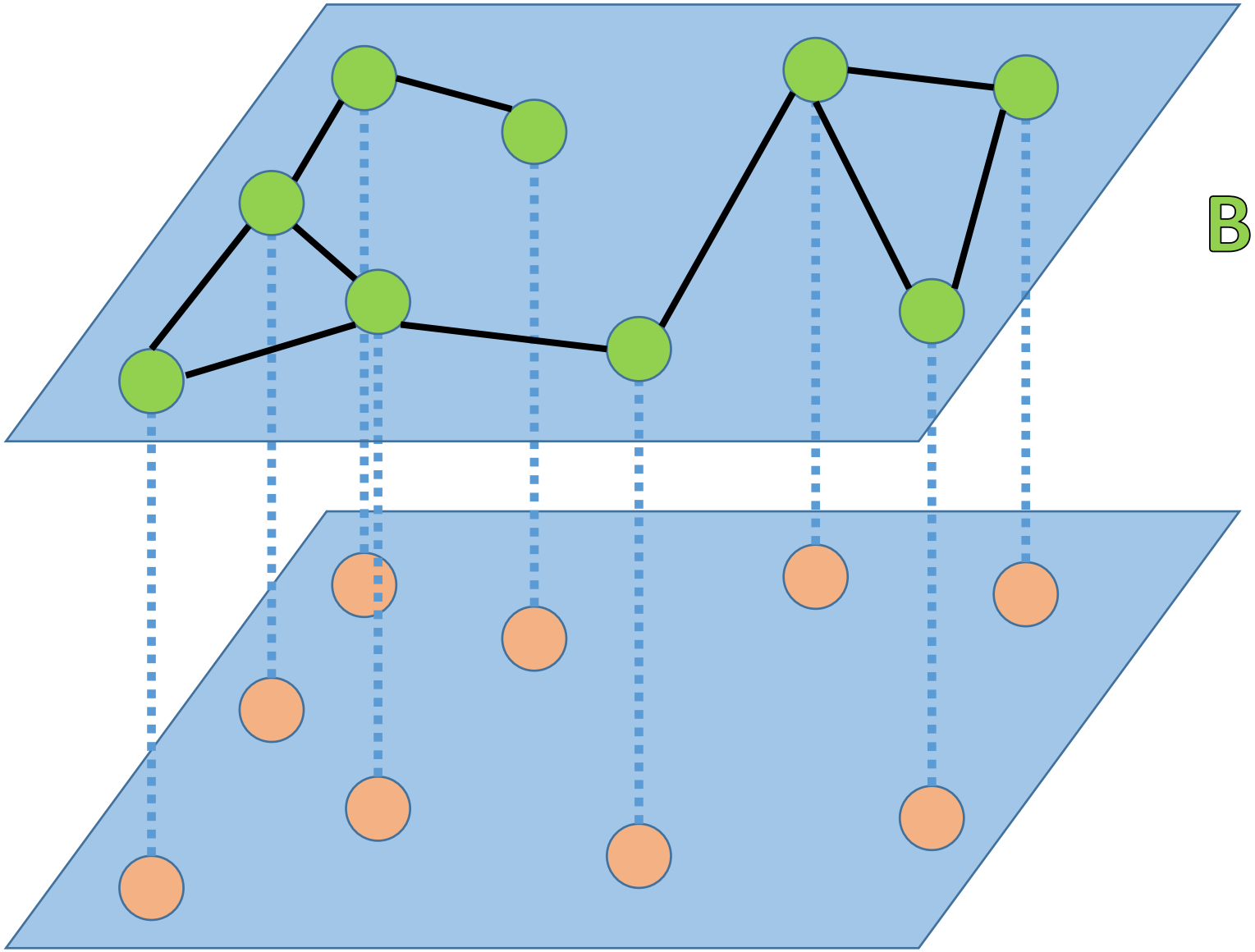

Biophysical Network

Social Network

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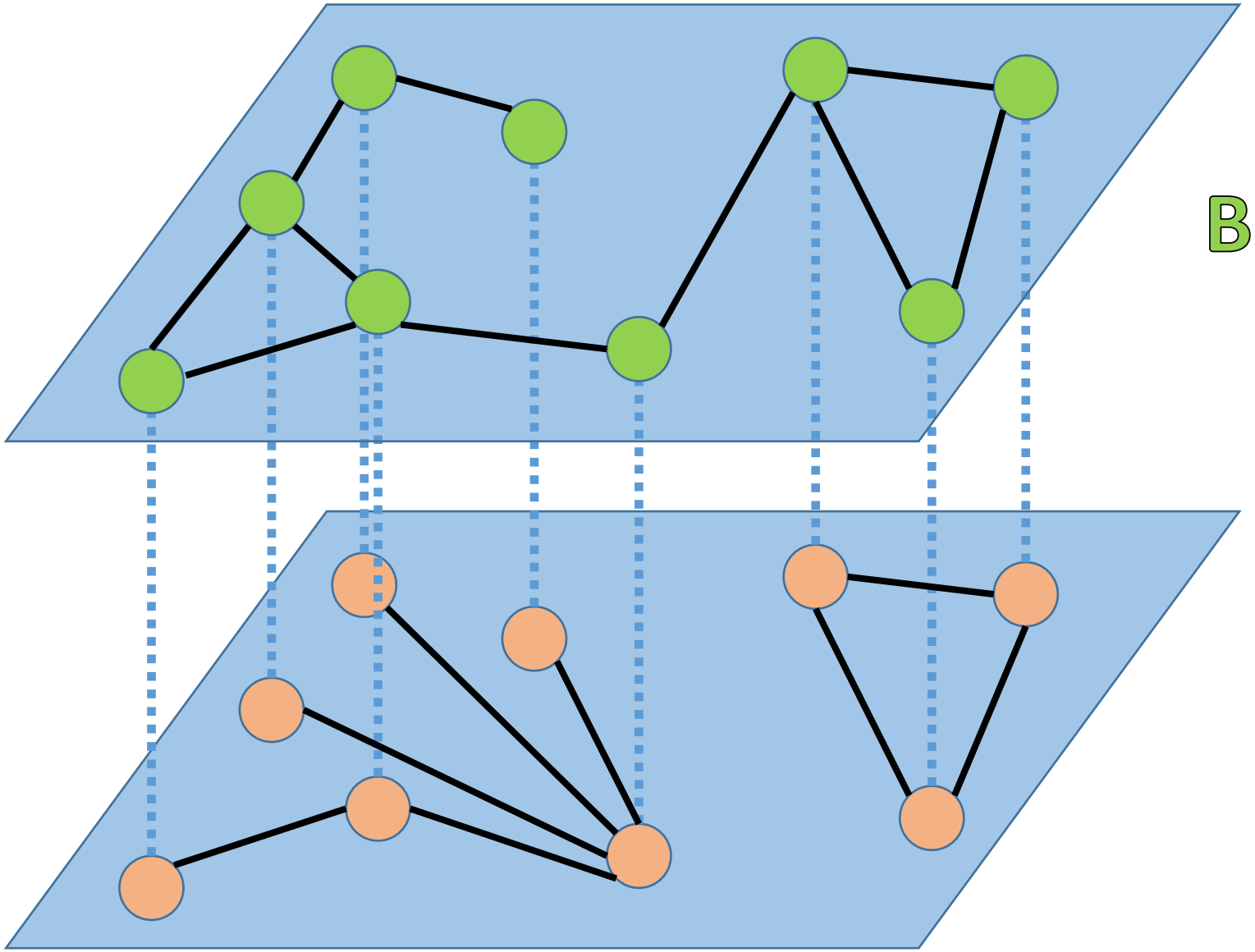

Biophysical Network

Social Network

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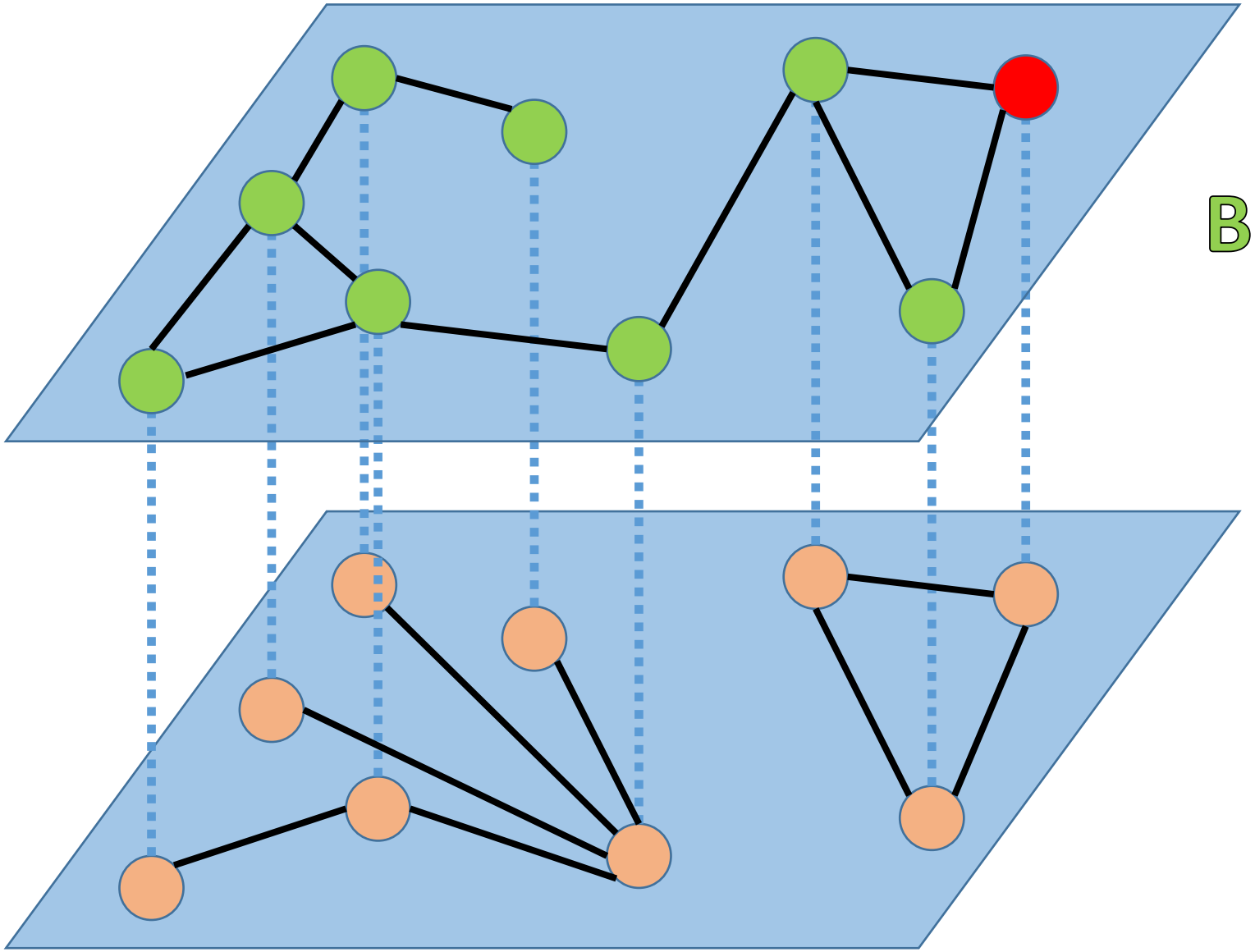

Biophysical Network

Social Network

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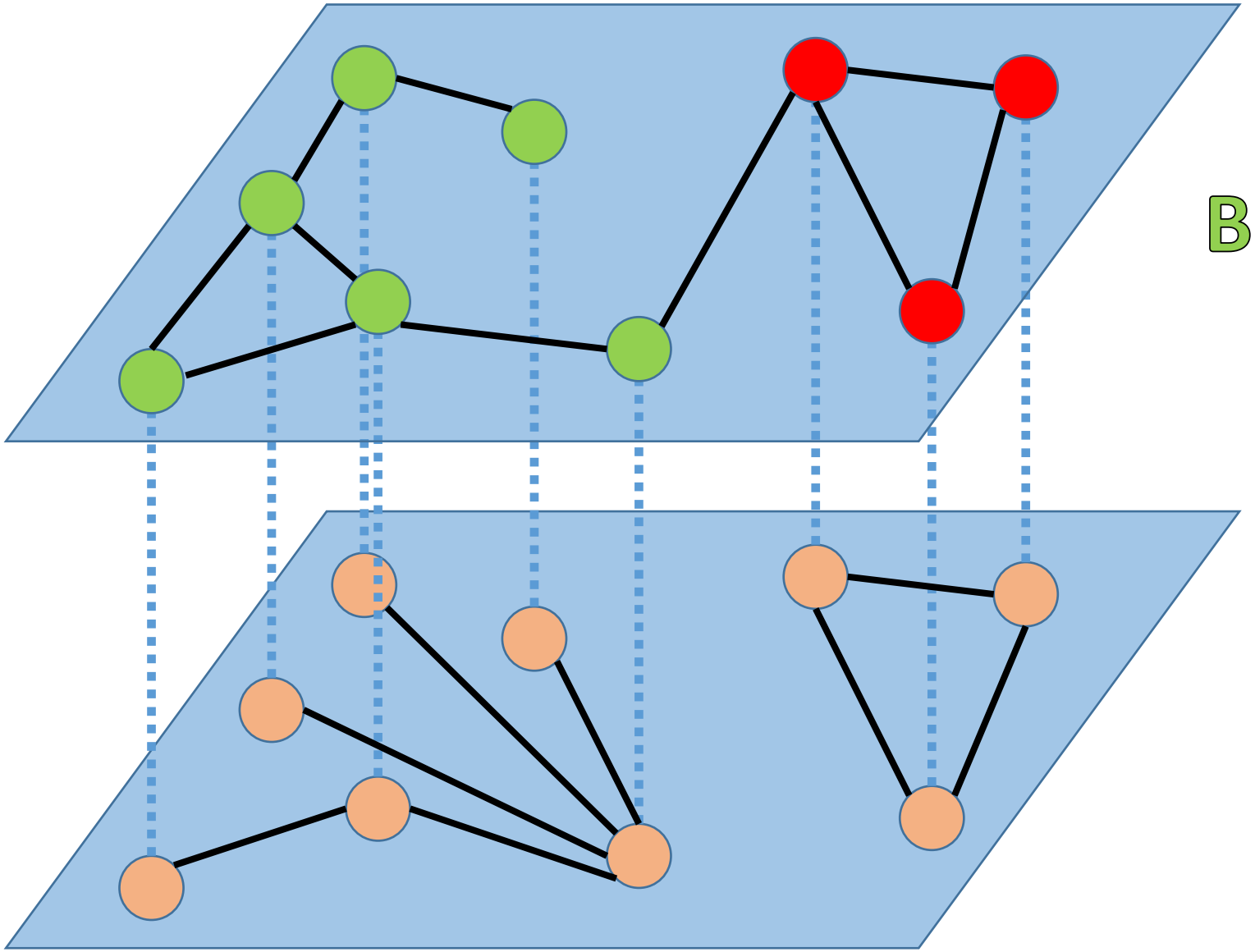

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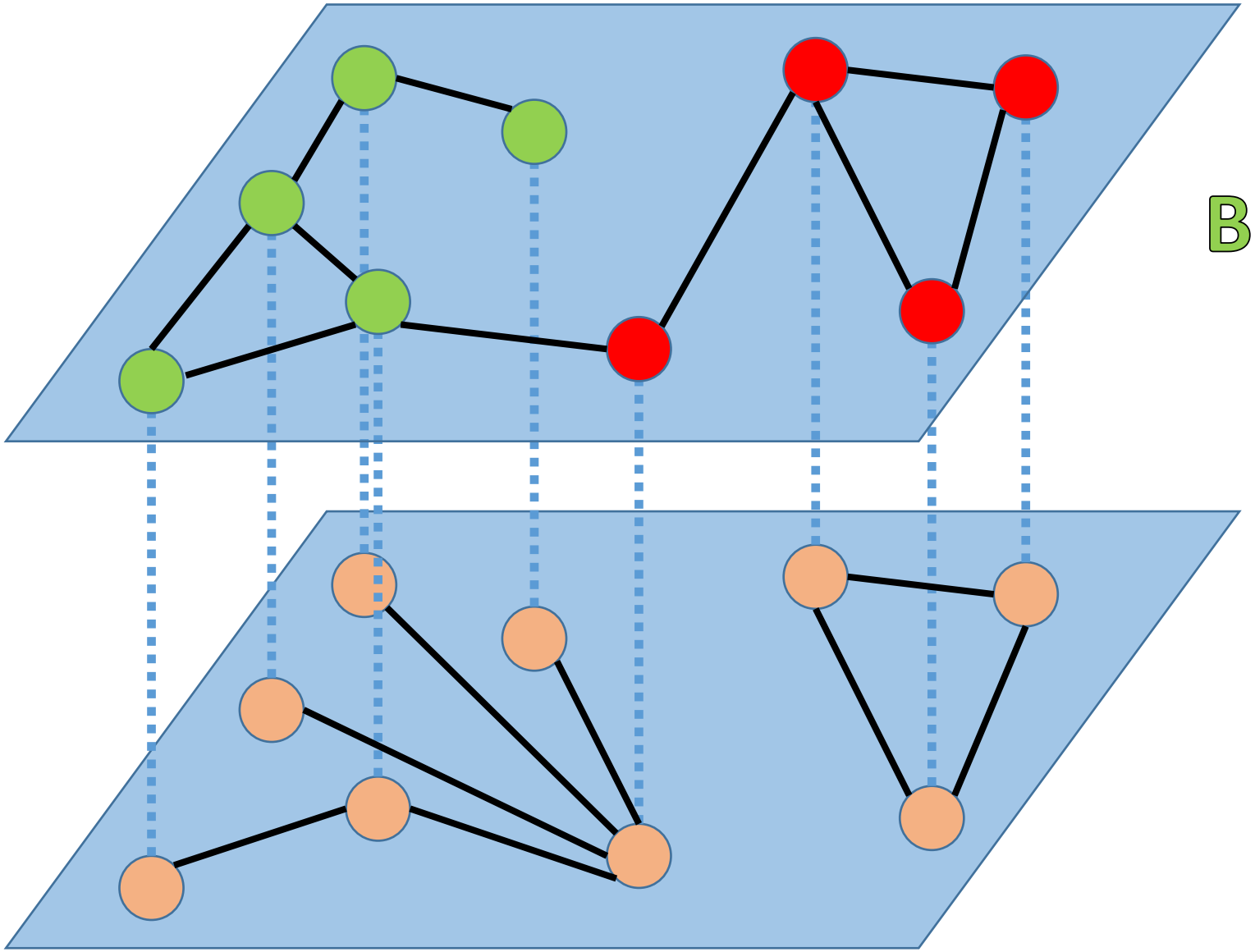

Biophysical Network

Social Network

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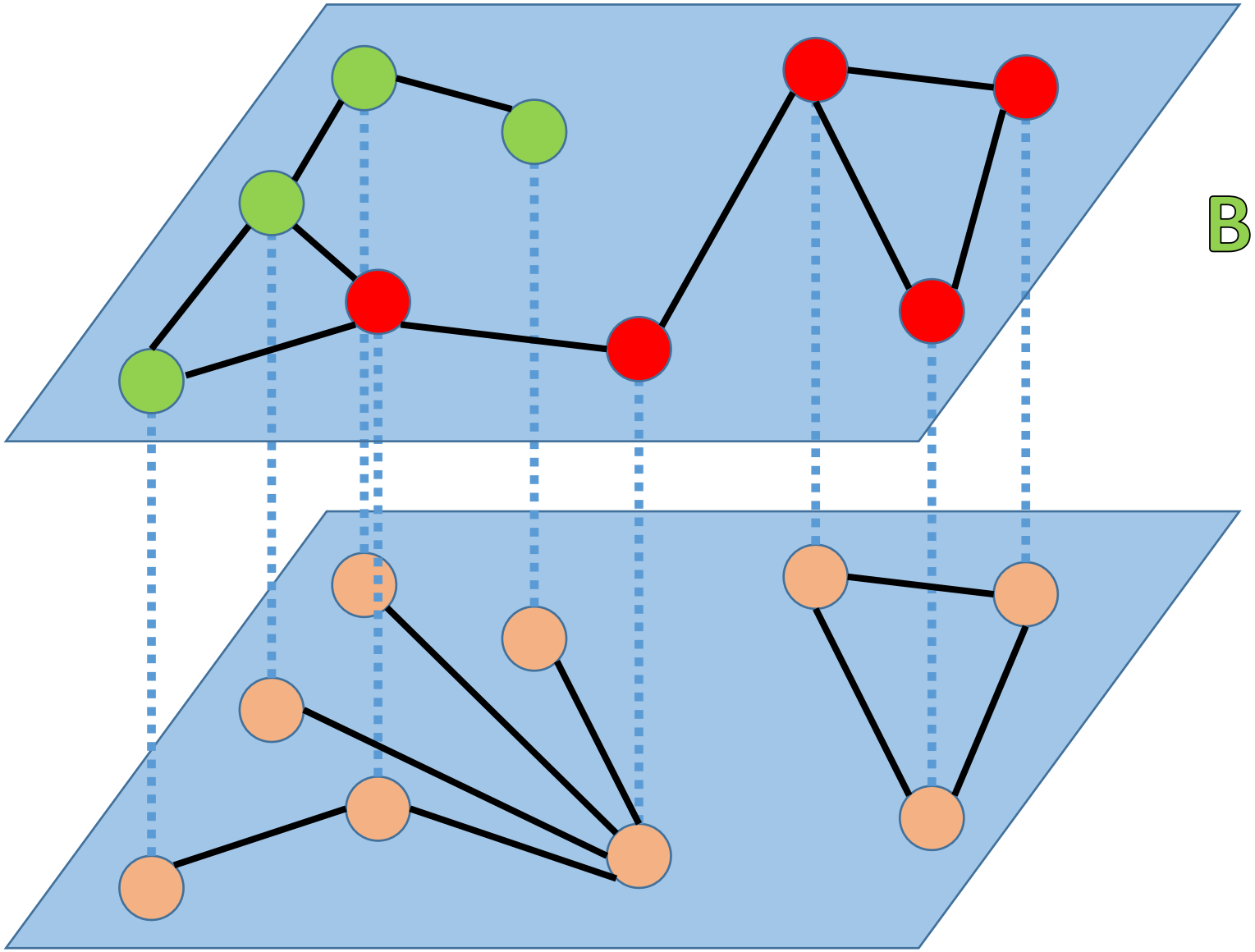

Biophysical Network

Social Network

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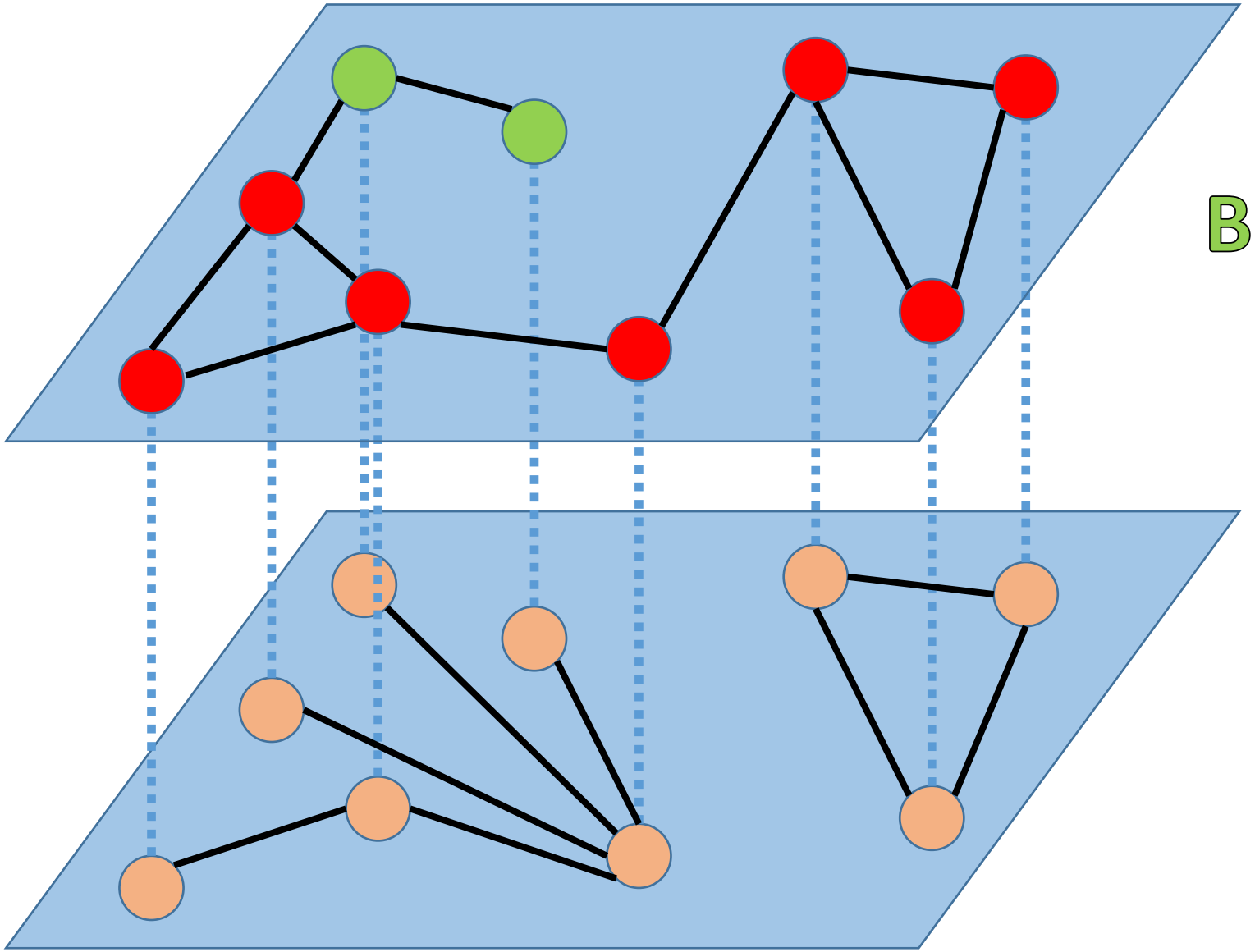

Biophysical Network

Social Network

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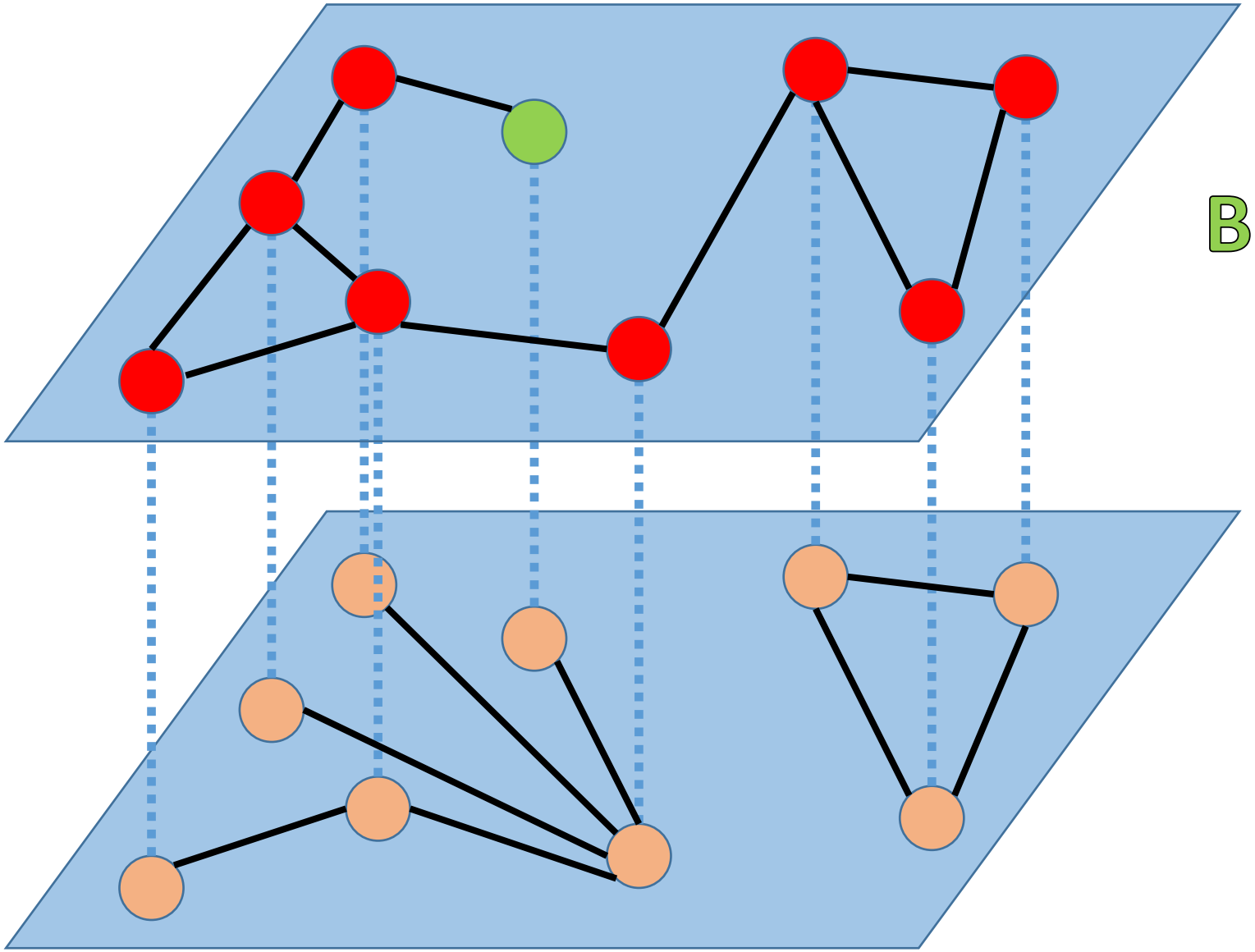

Biophysical Network

Social Network

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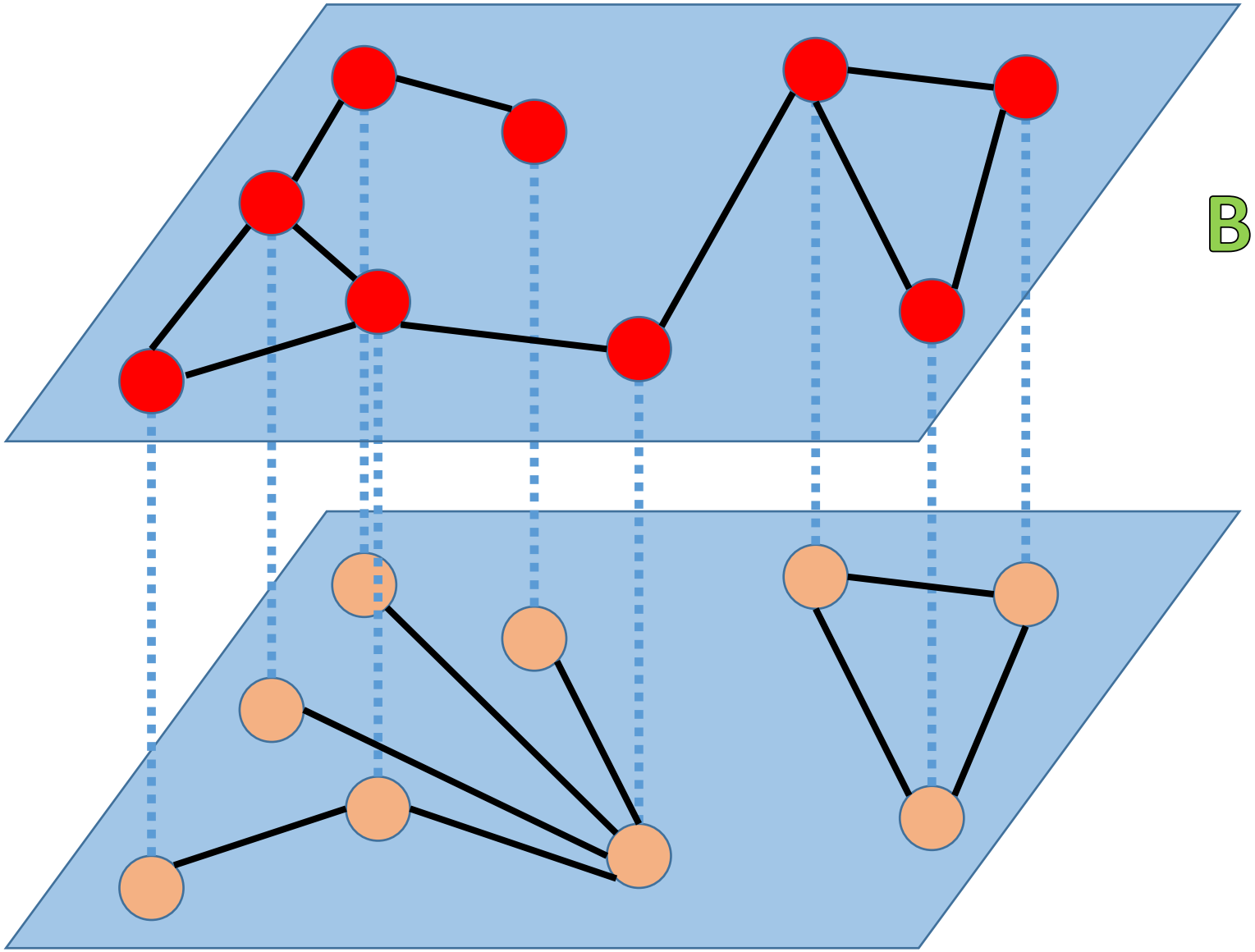

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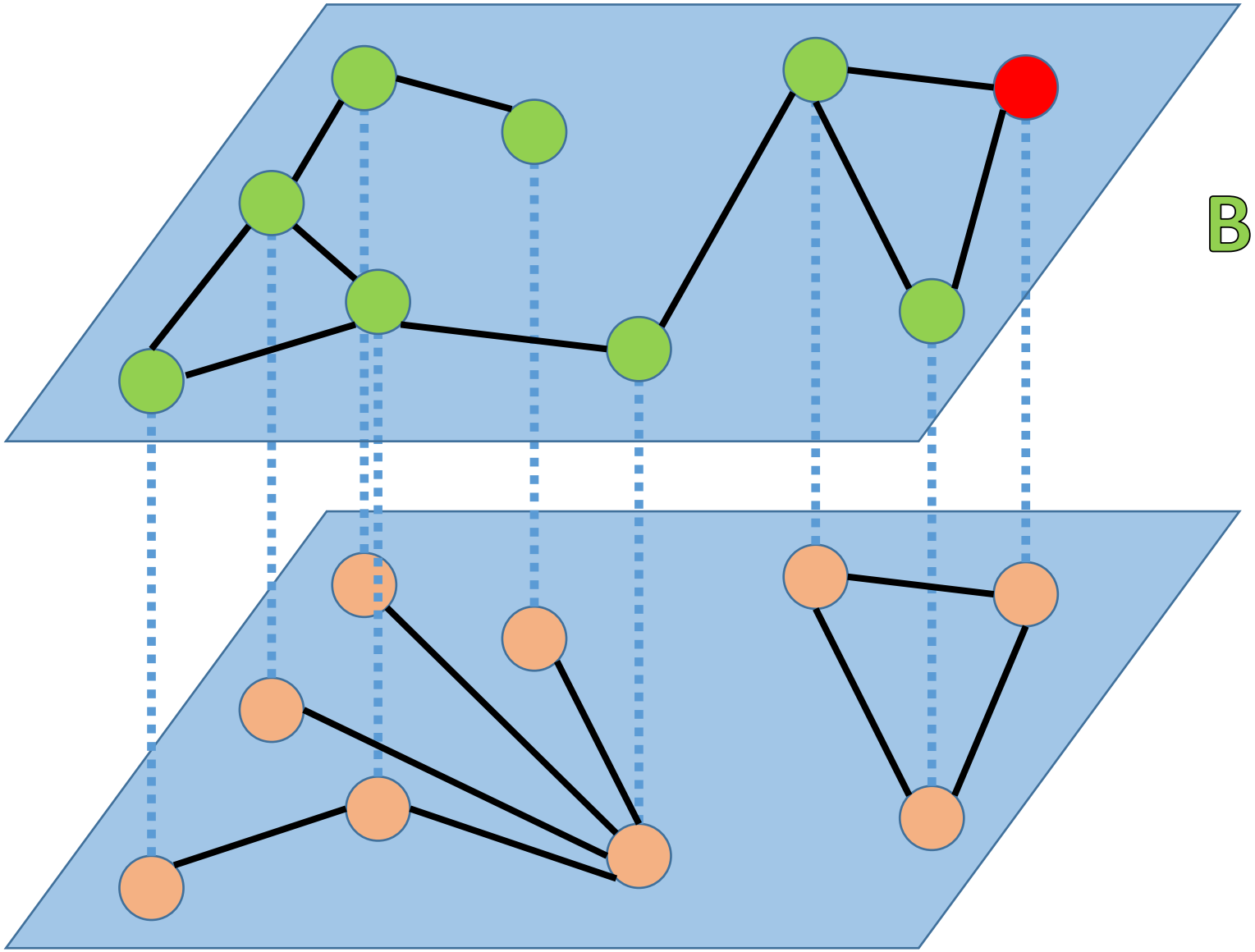

Biophysical Network

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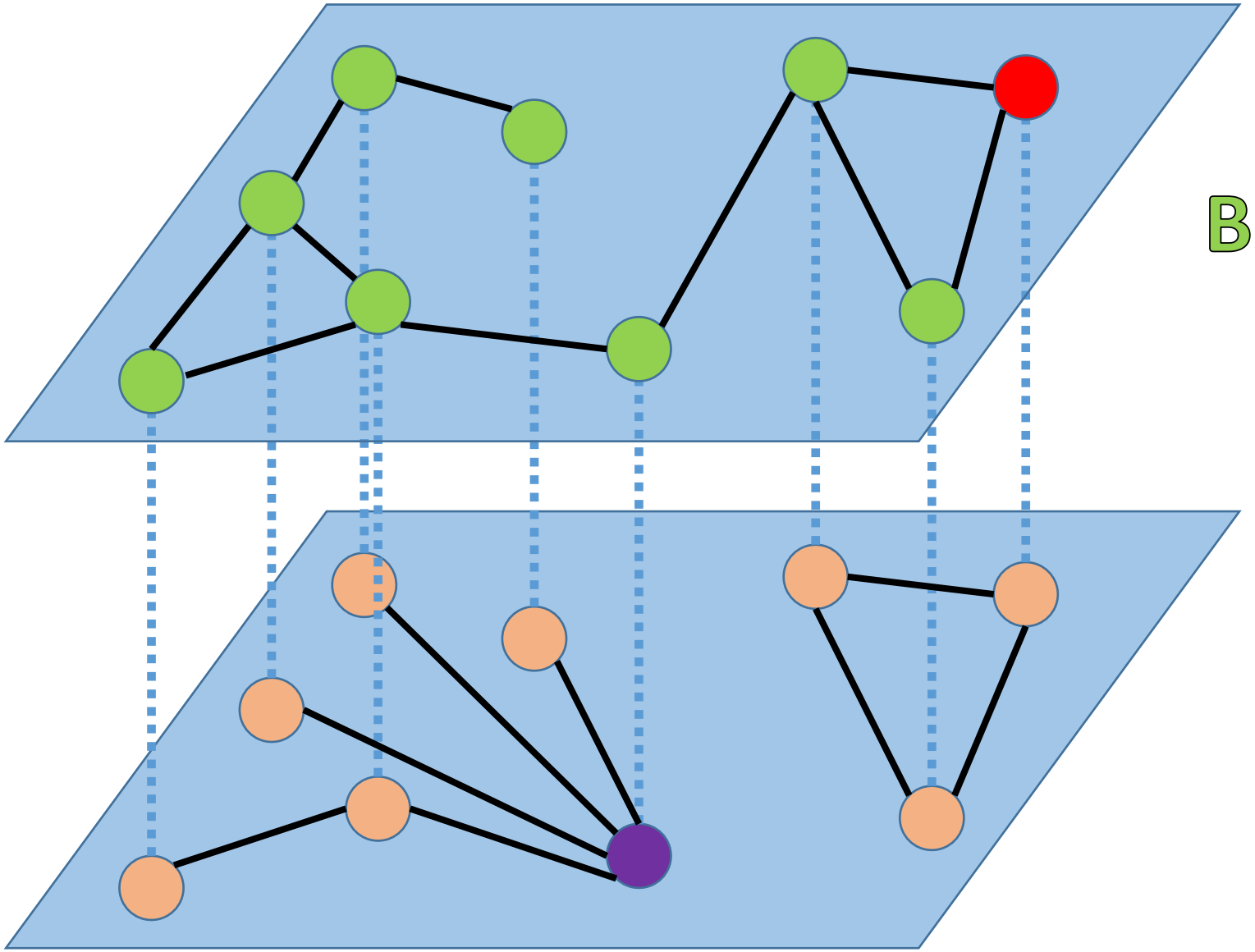

Biophysical Network

Social Network

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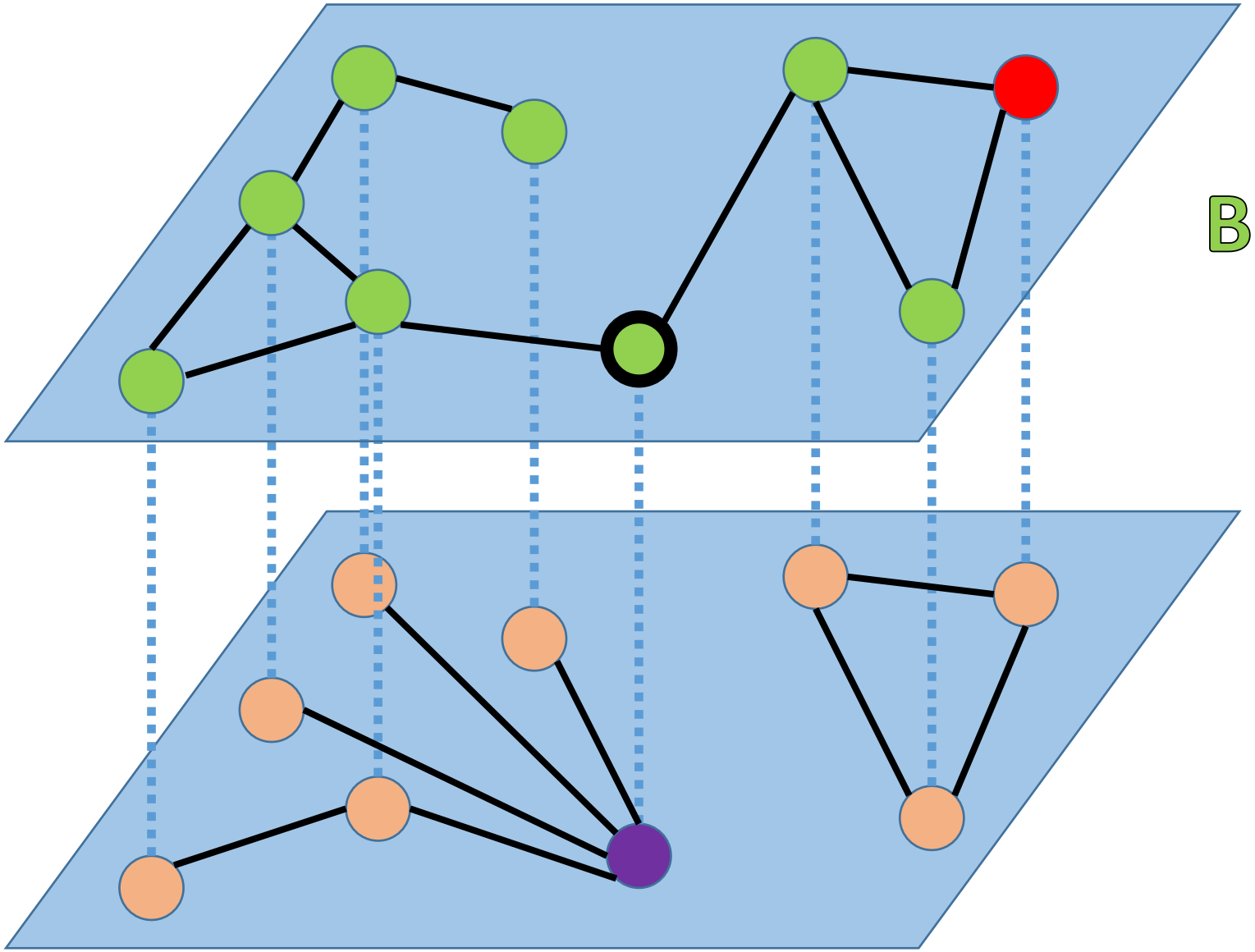

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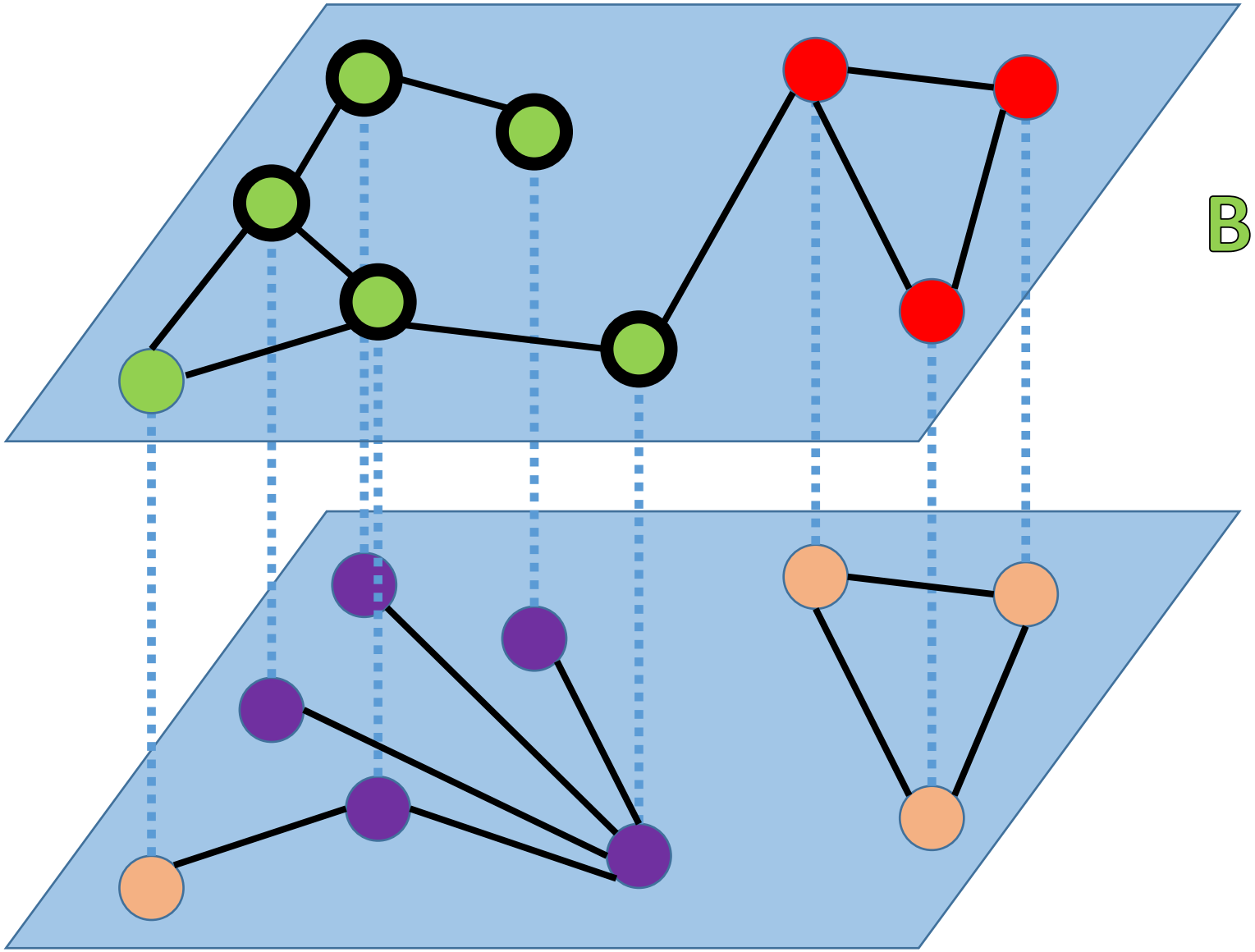

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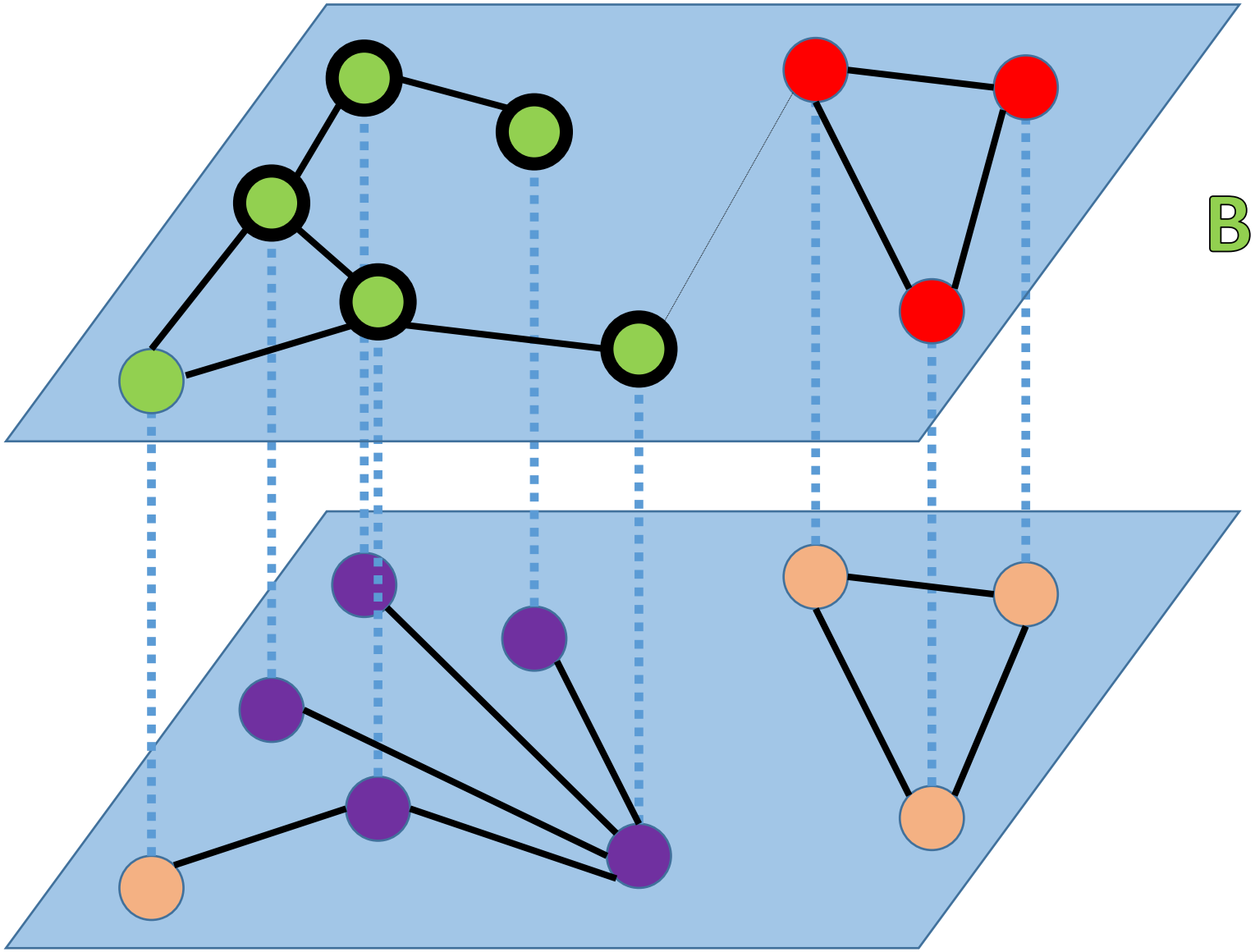

Biophysical Network

Social Network

Lots of Uses of Network Models in Plant Pathology