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Validation results from a multi-agent simulation of coupled travel and social behavior

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September 08

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Transportation planning fundamentals

Travel is a "price" to pay to go somewhere

Demand for travel periodically exceeds capacity of infrastructure

→Delays

Adaptive behavior

→Centralized: pricing of services

→Decentralized: People adjust their travel and their activities to services, traffic conditions, personal constraints

Almost always: independent utility maximizer

Interactions relevant to travel behavior

Information exchange / choice set

Knowledge (locations, activities, ideas)

Encounters

Disease, money, violence, company, etc.

Coordinated travel or activities

Social norms

Mode choice, trip frequency, total mobility

Altering social relationships due to distance

Moving house, changing jobs

Problem!

What social interactions are relevant?

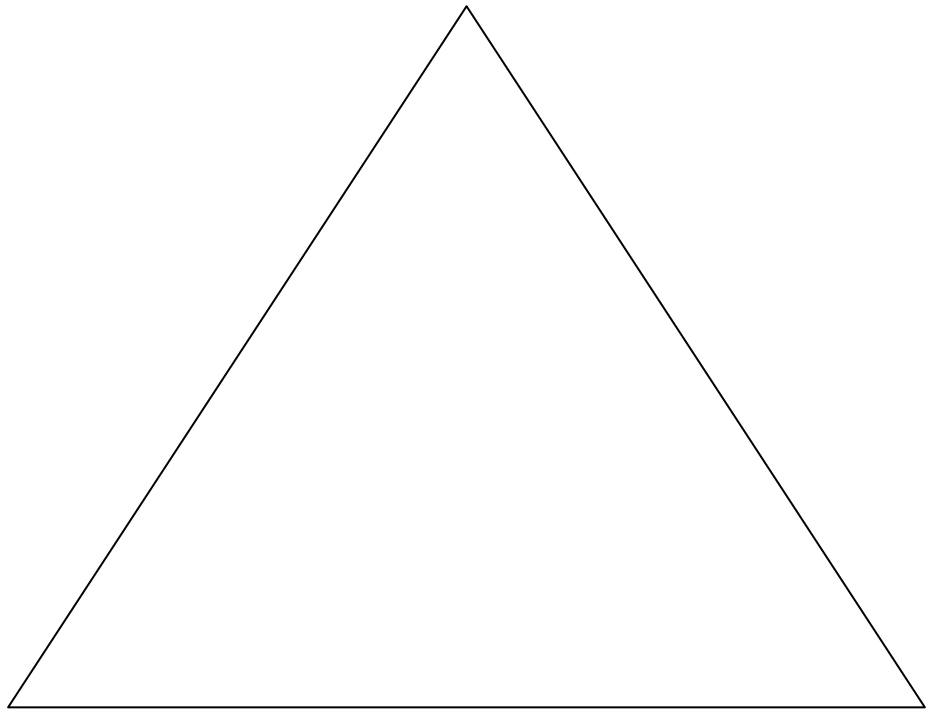
- -Density and topology of social networks
- -Geography
- -Biography
- -Sociodemographics
- -Role of activities / interests
- -Identified / Unidentified alters

Lack of data

Basis network generation algorithms

Social Processes

Depend on network/node attributes



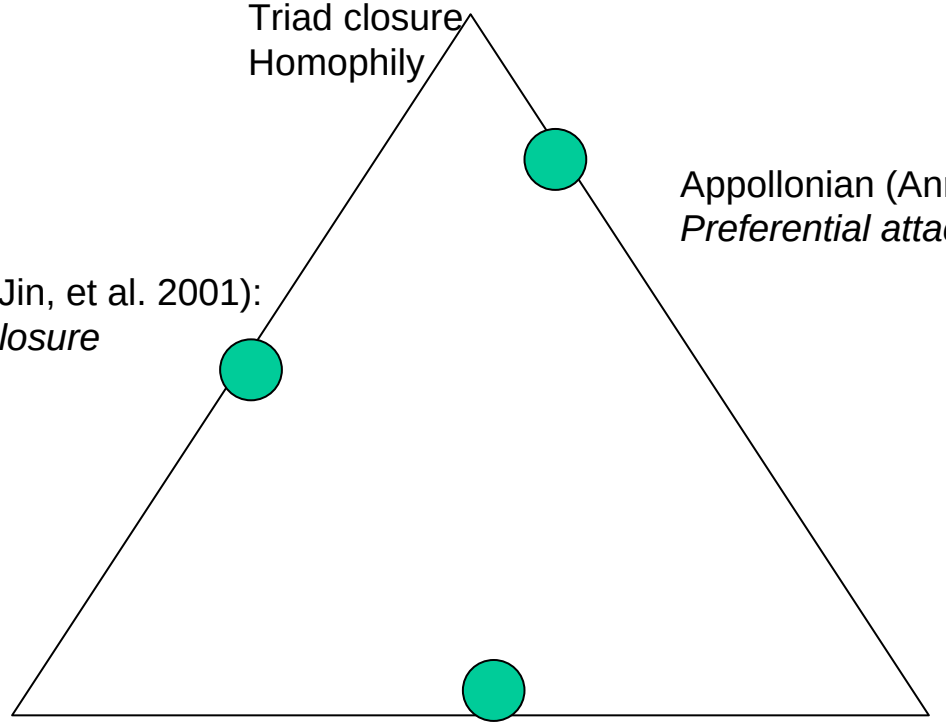
Random Processes

Independent of space and network/node attributes

Spatial Processes

Depend on space/geography

Hybrid network generation algorithms



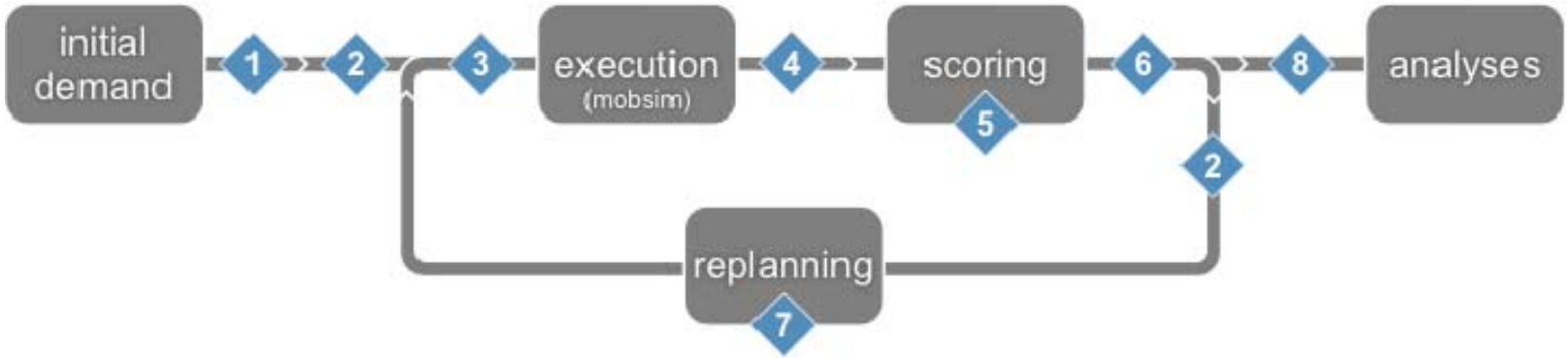
Erdös/Renyi
- Mean field models
- Ideal gases

Spatial small-world (Watts 1999)
Small world + 2D lattice

Spatial small-world (Wong et al. 2006)
Erdös/Renyi + 2D distance

Crystal lattices
Geographical boundaries
Time costs and budgets

Evolutionary adaptation of activity-travel



1 Startup:	initialize social network initialize knowledge	5 Scoring:	update time window map
2 Iteration Starts:	exchange knowledge spatial meeting	6 Iteration Ends:	remove social links output statistics
3 Before Mobsim		7 Replanning	use agents' knowledge to alter plans
4 After Mobsim		8 Shutdown	

Based on: Rieser, 2008

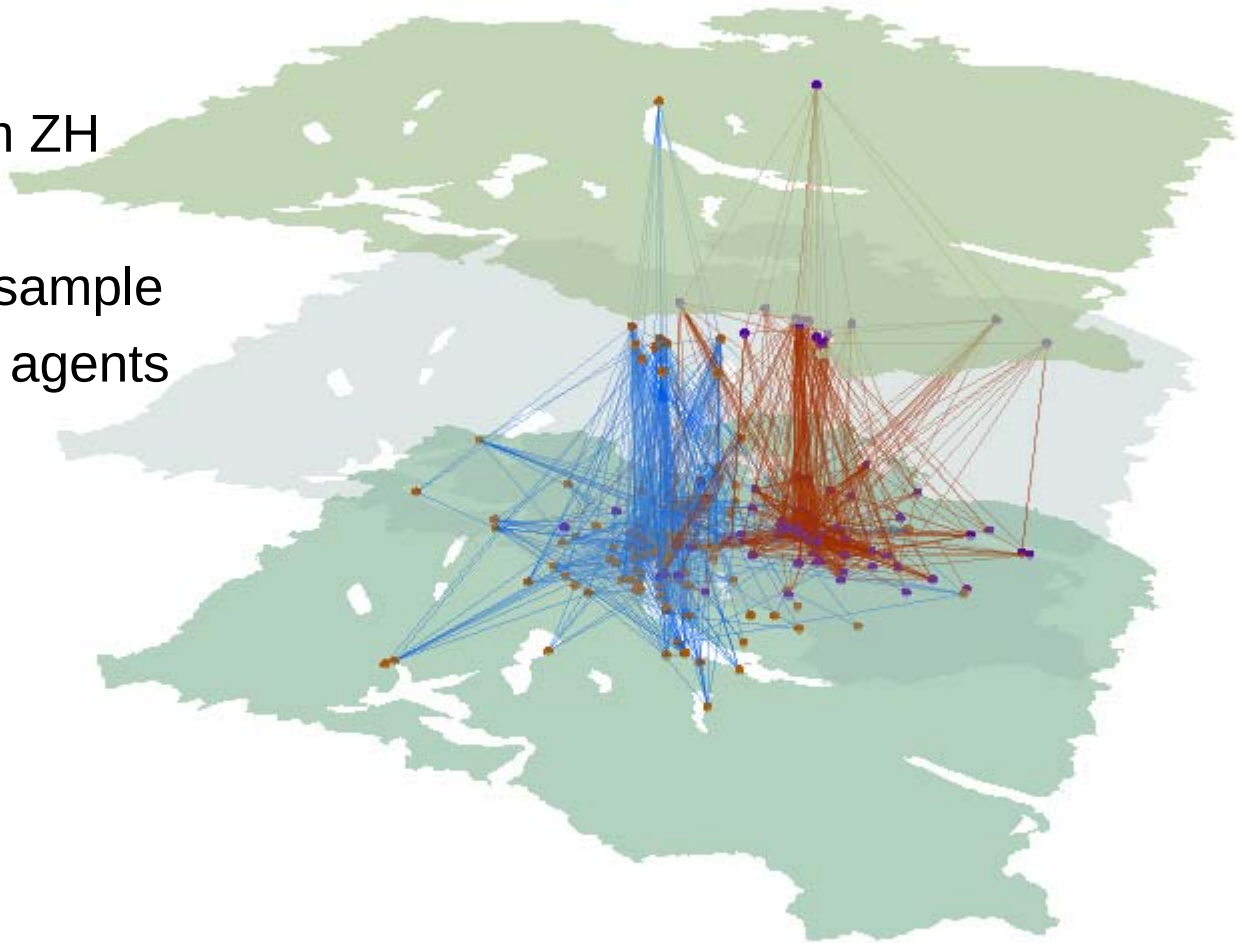
MATSim
Multi-Agent Transport Simulation

Validation world

100km x 100km ZH

1% population sample
= 8760 agents

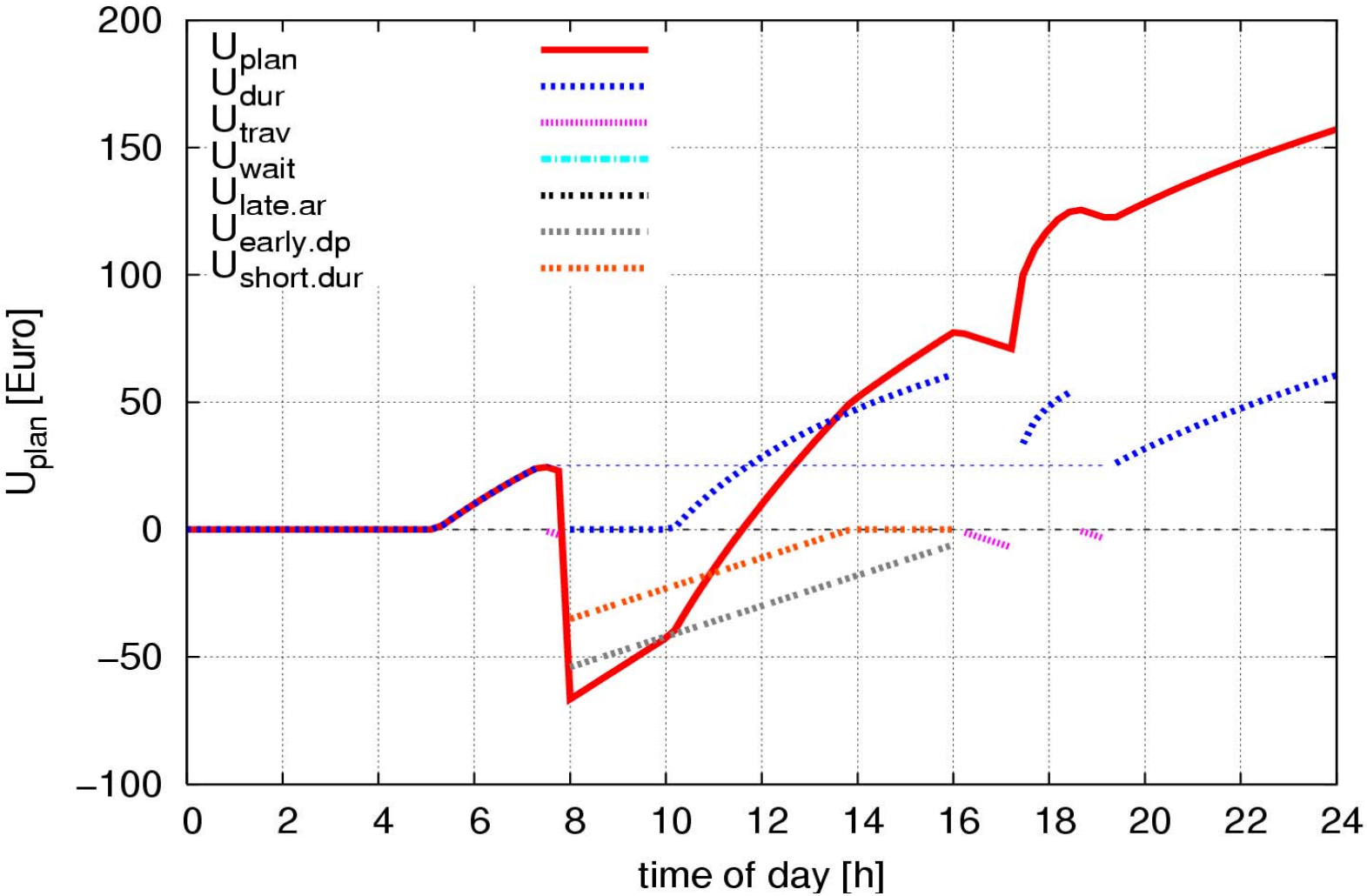
3.4 trips/day



Validation runs

Test	0	1	2
Initial social network	None	$Dist^{(-1.5)}$ Constant z=12	Evolving
Interactions	None	Exchange 1 location per dyad	
Re-Planning	Time Route Logistic	Time Route Logistic Location	
Social network evolution	None	Make 1 friend, Constant z	
Score	Standard	Standard + Ln(Nfriends)	

Utility of a Day Plan with 3 Activities

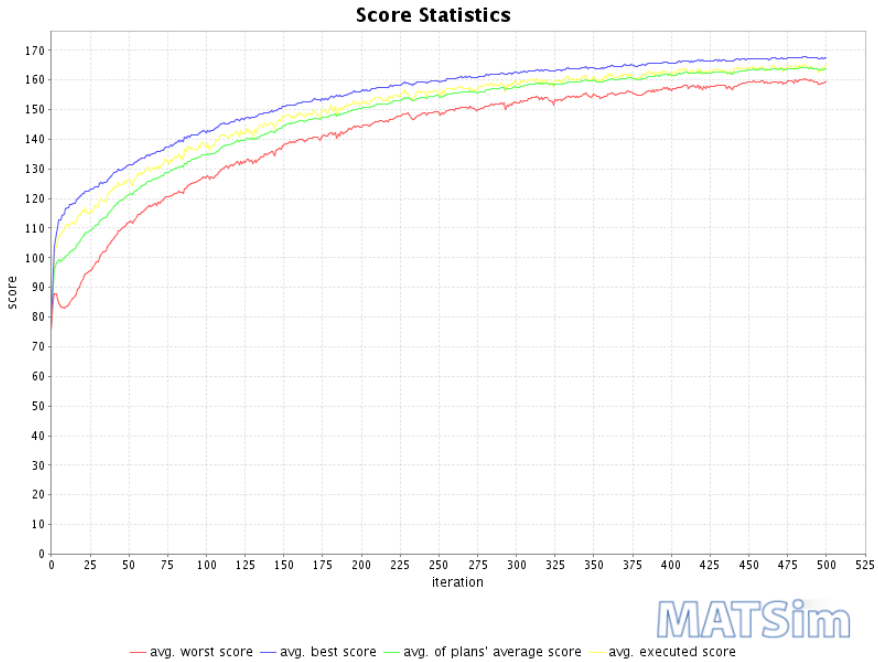


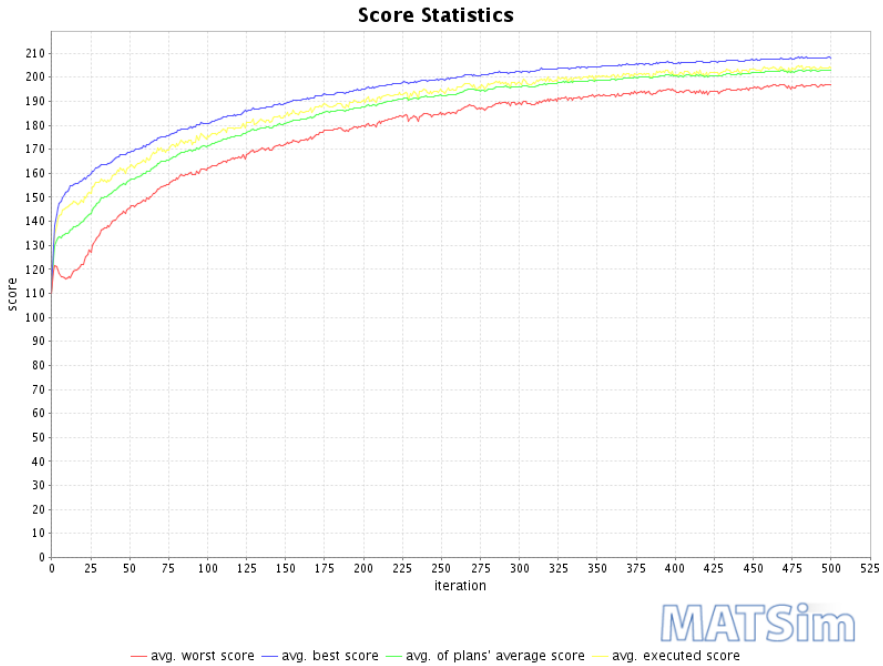
Source: David Charypar 2007

Validation runs

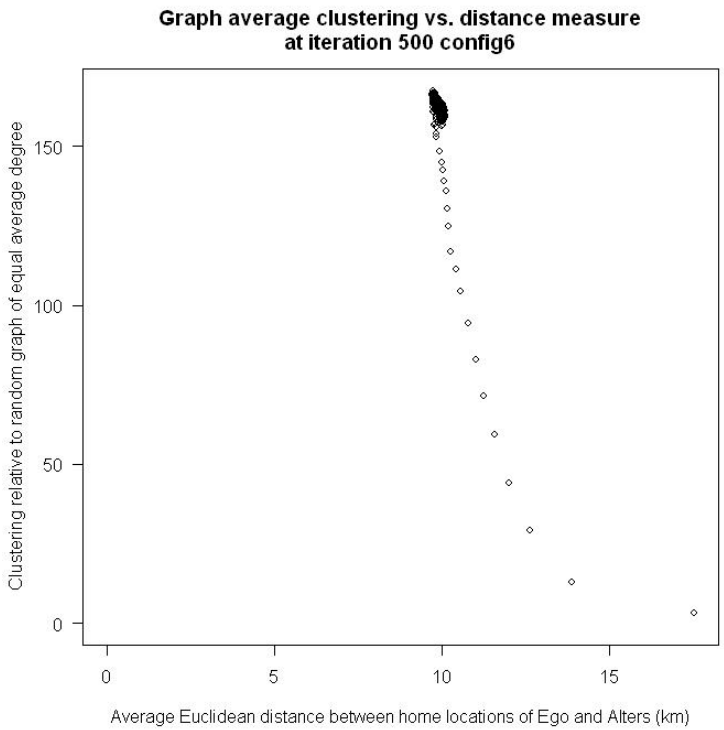
Name	Type	Social net	Social interact	Score	Replan	Iterations	Runtime
Config1	reference	0	0	0	0	500	1.7GB, 11.5hrs
Config7	reference	0	0	0	2	500	1.7GB, 15hrs
Config2	SN_time	1	0	1	0	500	3.5GB, 14.5hrs
Config3	SN_loc	1	1	1	1	500	3.9-4.2GB, 21hours
Config4	SN_loc	1	1	0	1	500	3.9-4.2GB, 21hours
Config5	SN_loc_Dyn_1	2	1	0	1	500	3.9-4.2GB, 21hours
Config6	SN_loc_Dyn_2	2	1	1	1	500	3.9-4.2GB, 21hours

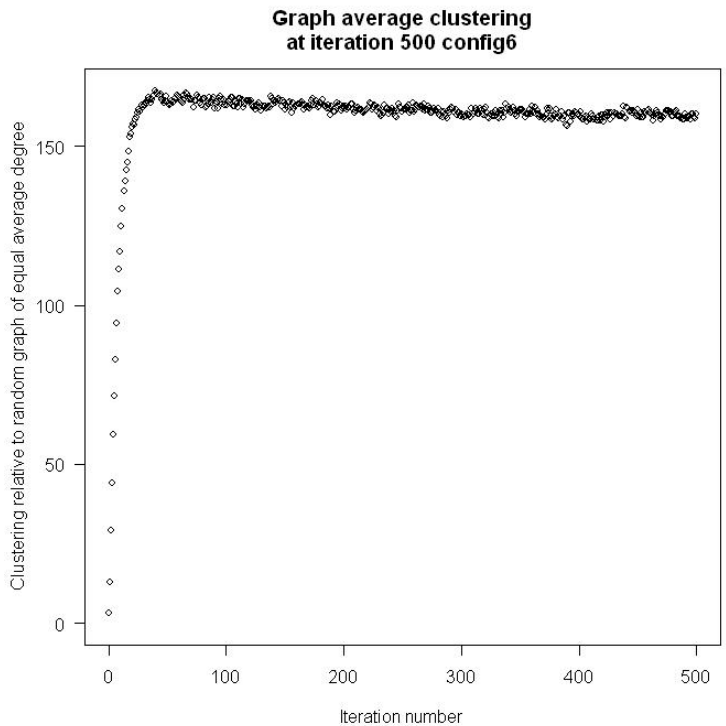
Equilibrium?





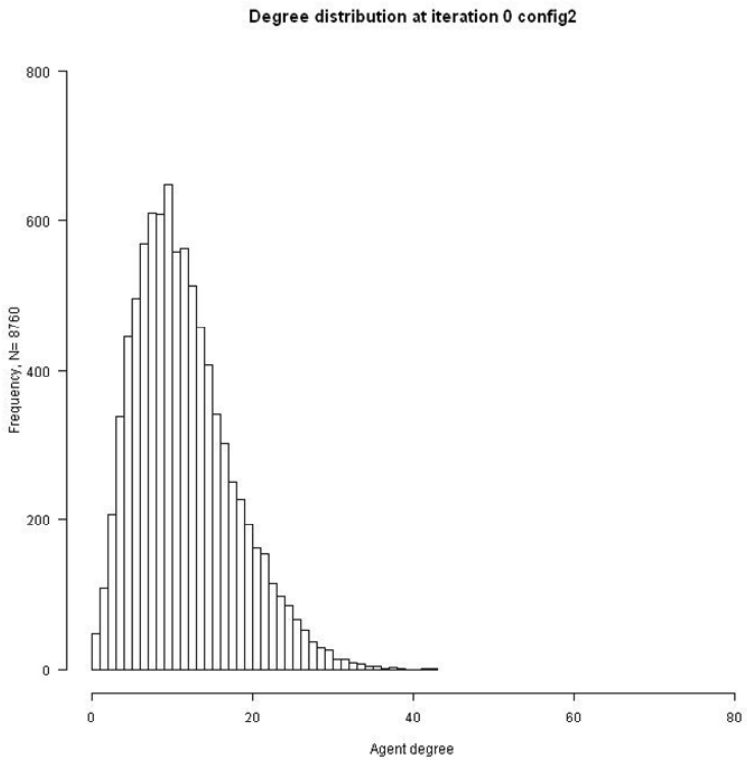
Equilibrium?

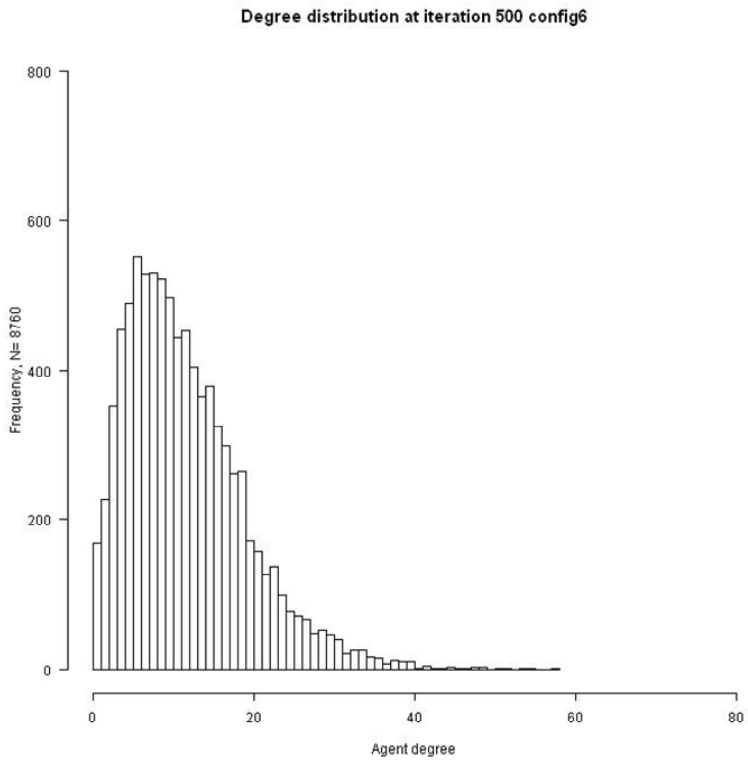




Degree distribution of static and evolved social network

(a) (b)

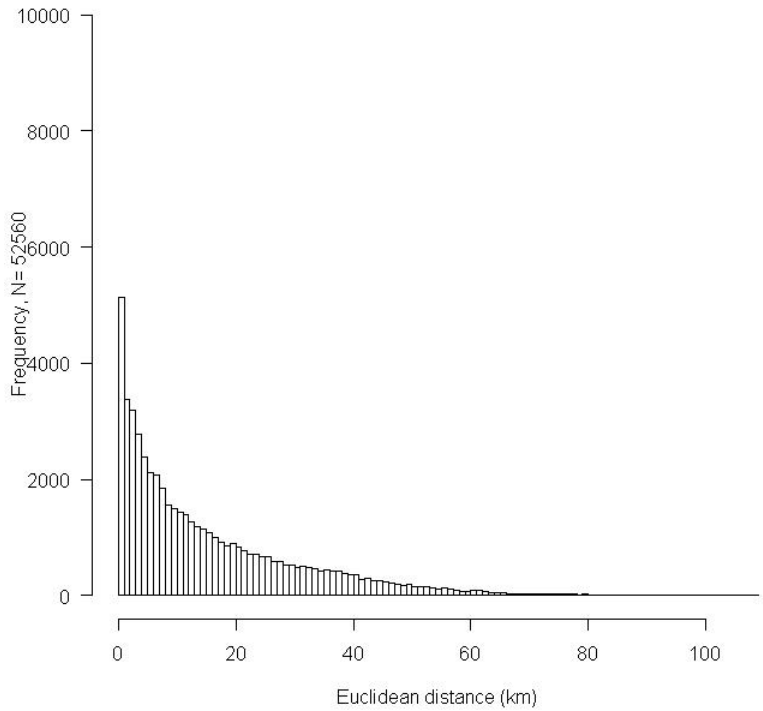


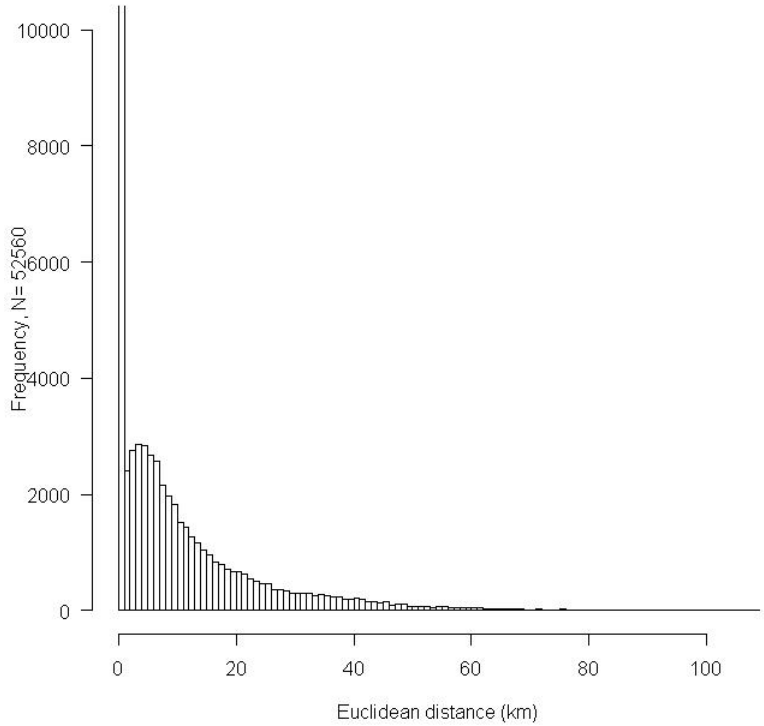


(a) Static network and initialization, Config2, 3, 4

(b) Network which evolved with activity plan optimization, Config6 (Config5 similar)

Euclidean distance between dyad members



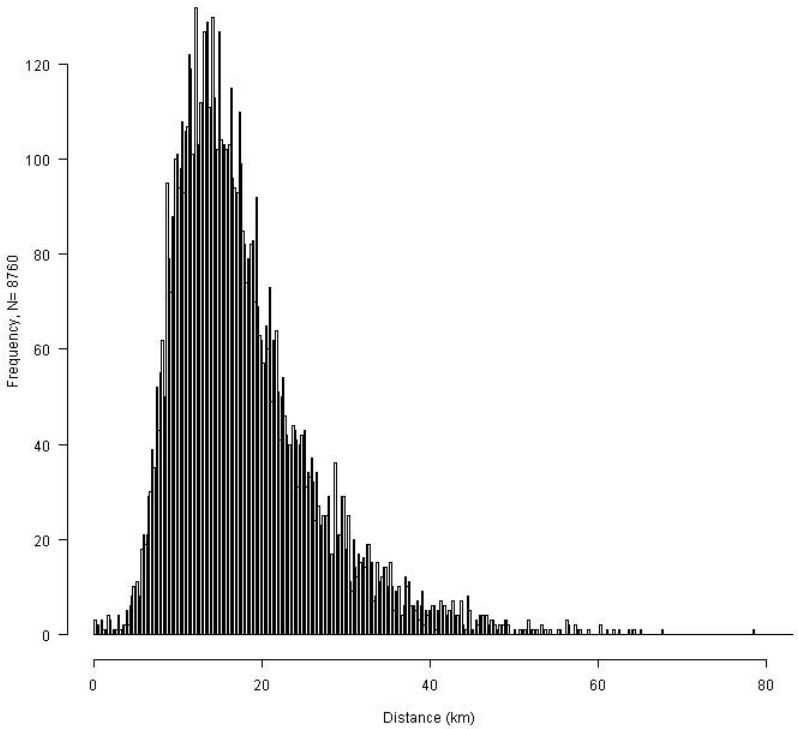


Static social network
15.4 km

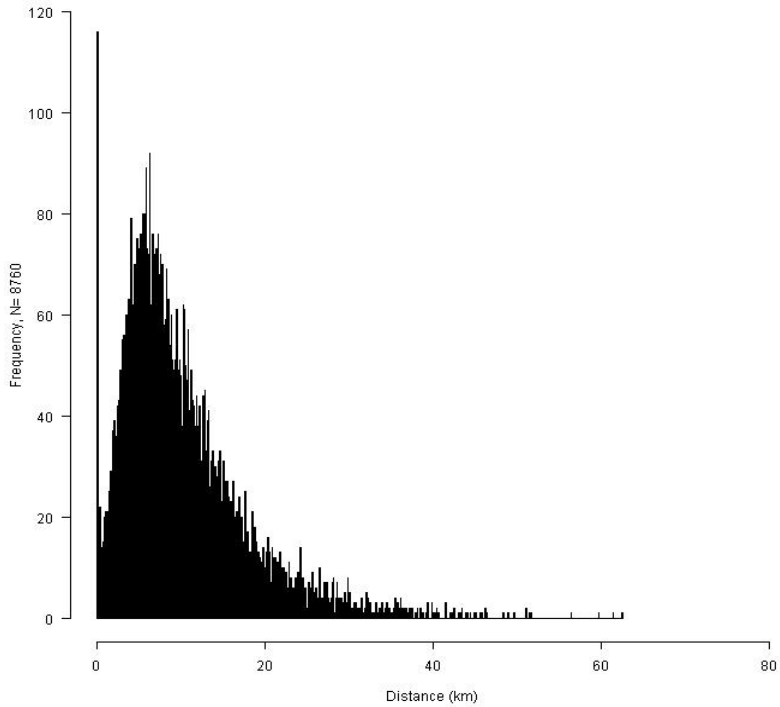
Evolved social networks
11.7 km

<d> = 31 km Dunbar(1997)

Average Euclidean radius of ego net

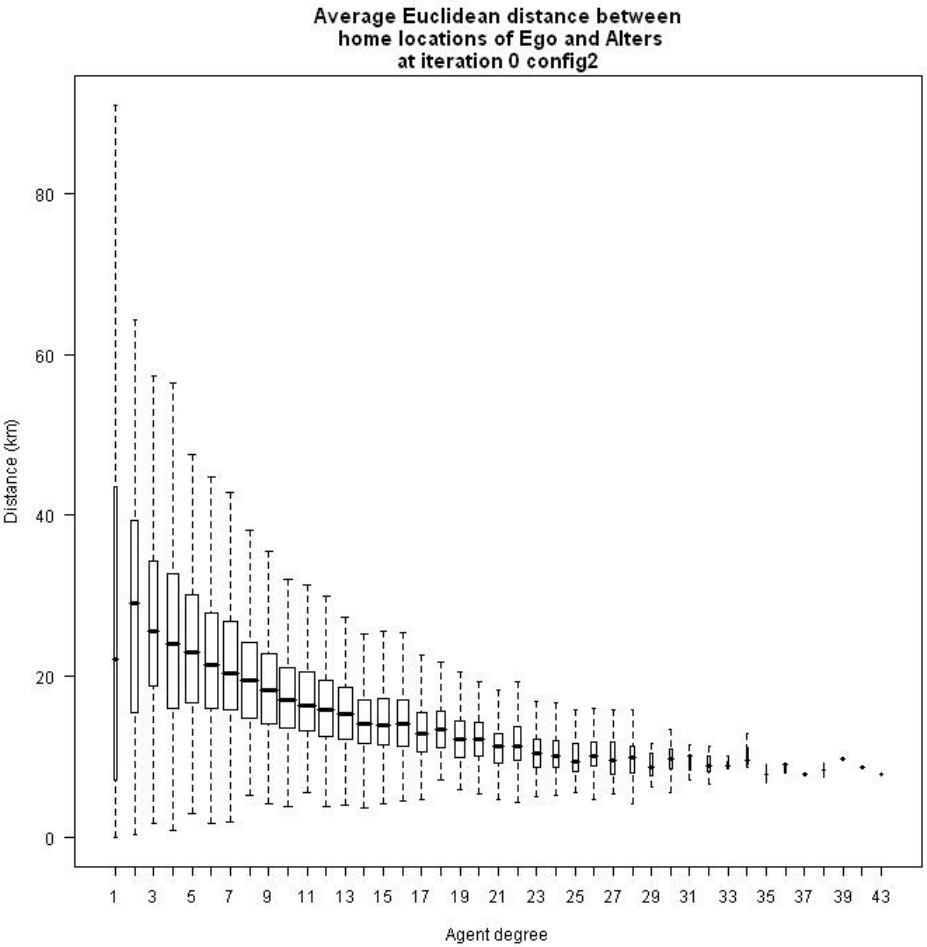


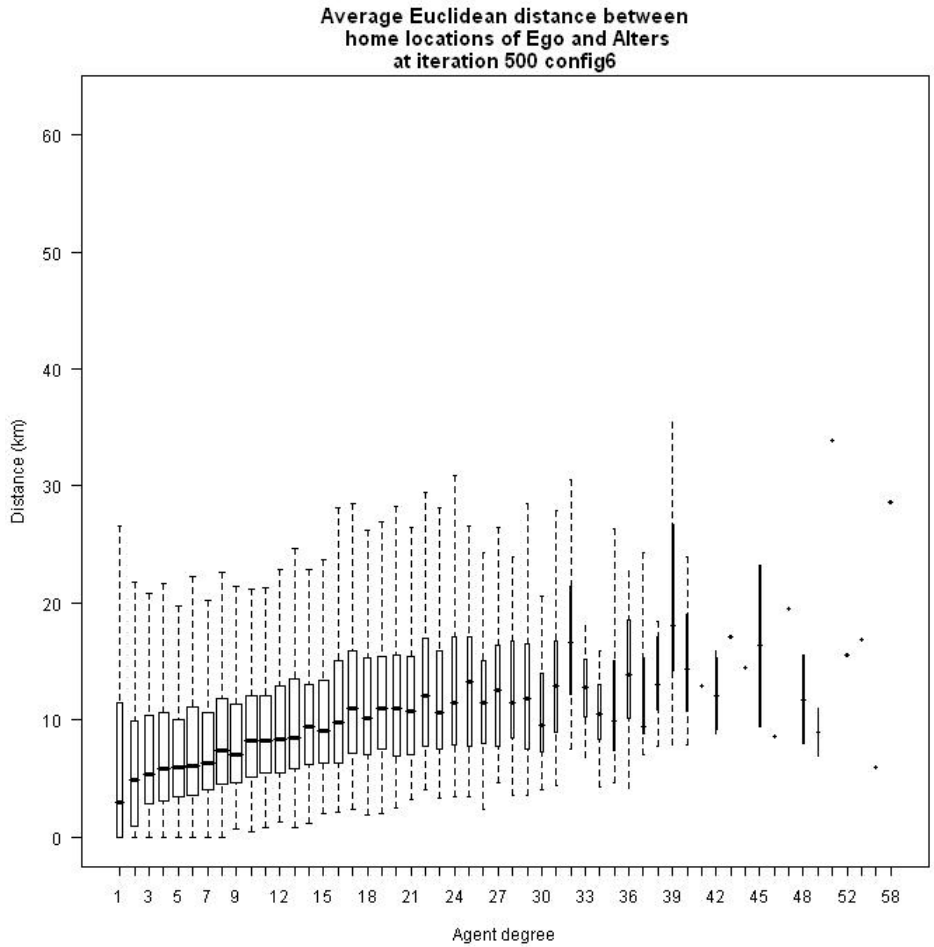
Static social network
17.6 km



Evolved social networks
10.4 km

Average Euclidean radius of ego net





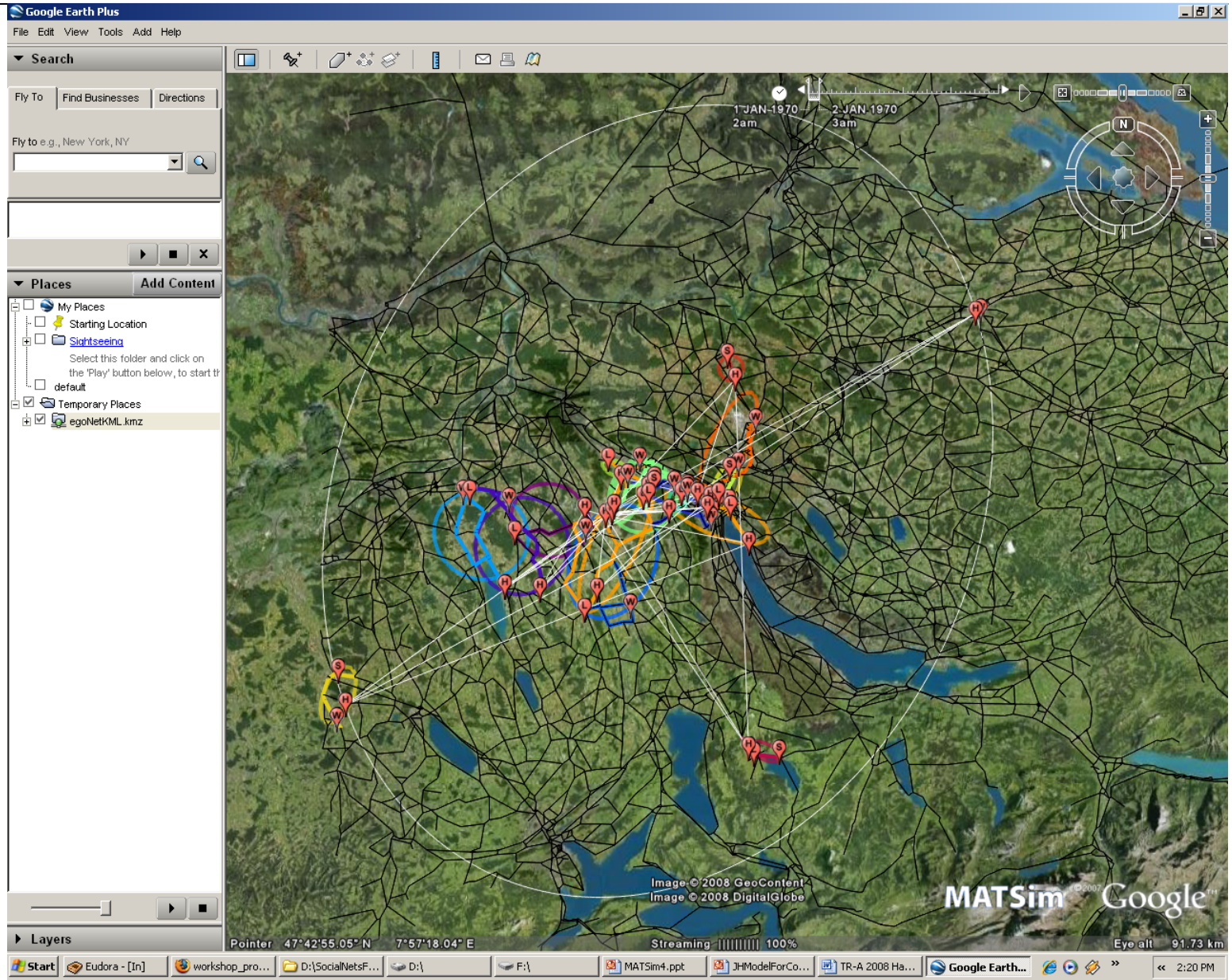
Static social network

Evolved social networks

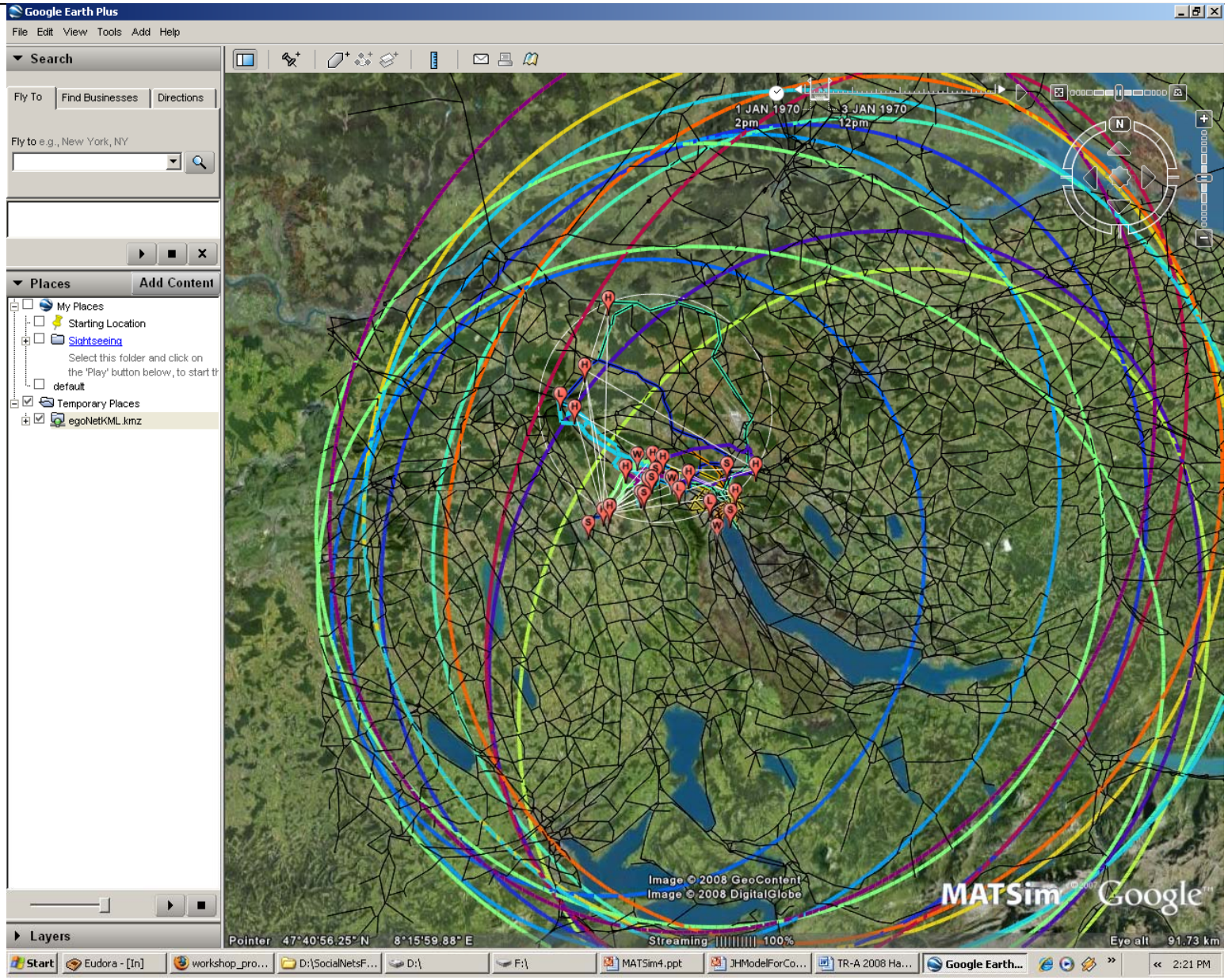
Other socializing indicators

Scenario	Components	Clustering Ratio	Diameter	Last met	Number met at leisure
1	8760	NA	NA	NA	0.1
7	8760	NA	NA	NA	0.1
2	11	3.24	9	NA	0.2
3	11	3.24	9	NA	0.3
4	11	3.24	9	NA	0.1
5	166	162	12	3.5	2.2
6	162	155	11	3.5	2.9

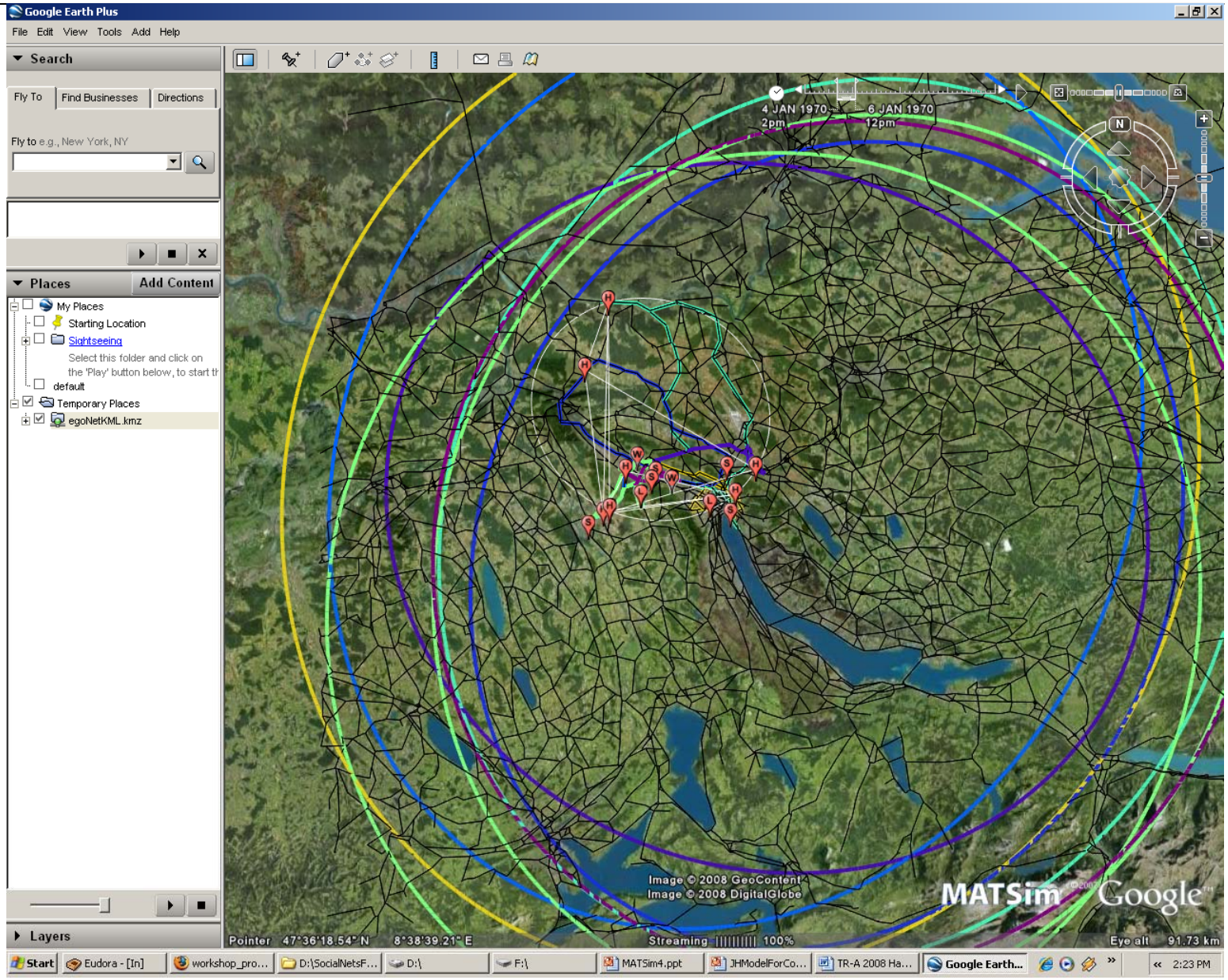
Spread of knowledge 0



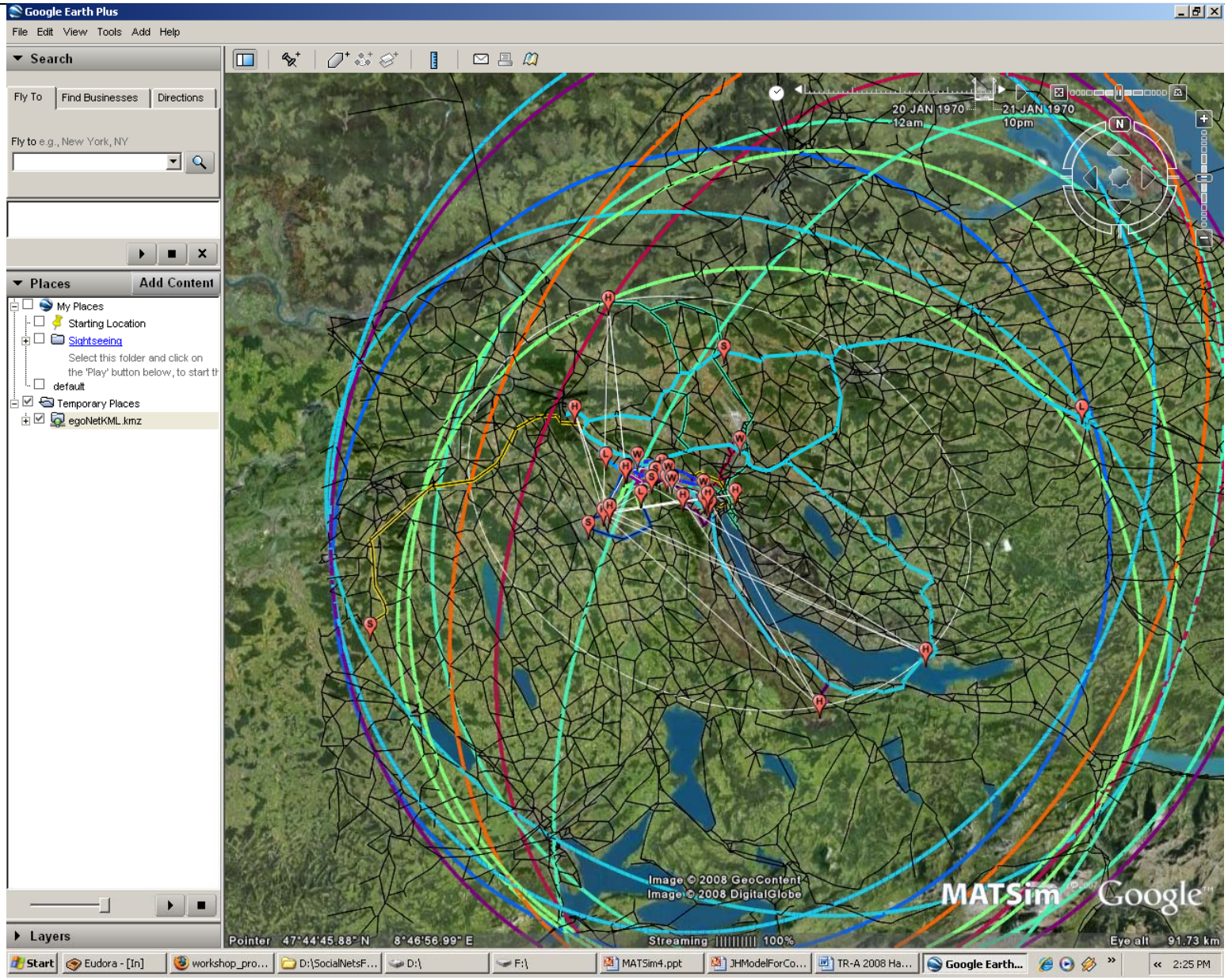
Spread of knowledge 50



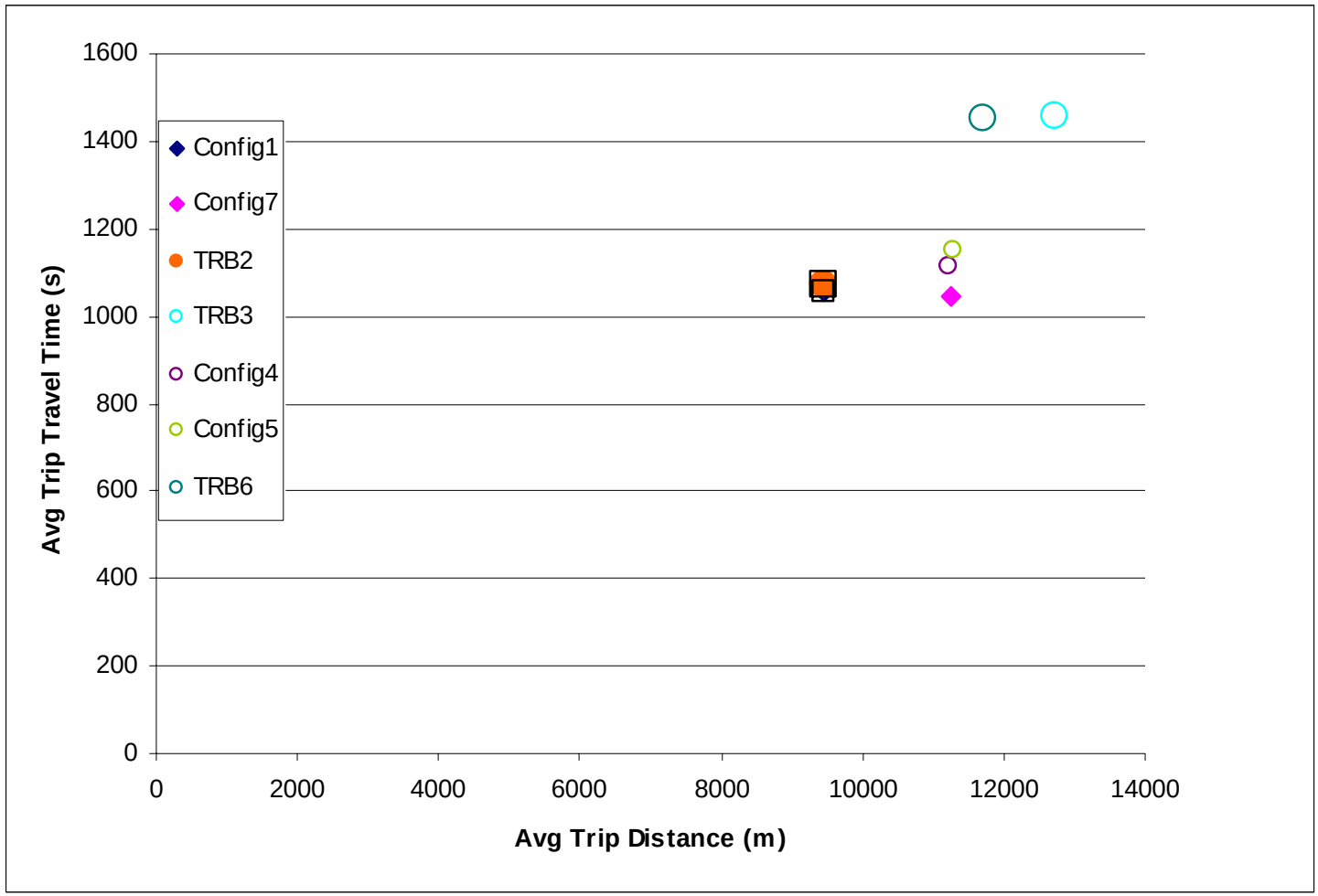
Spread of knowledge 100



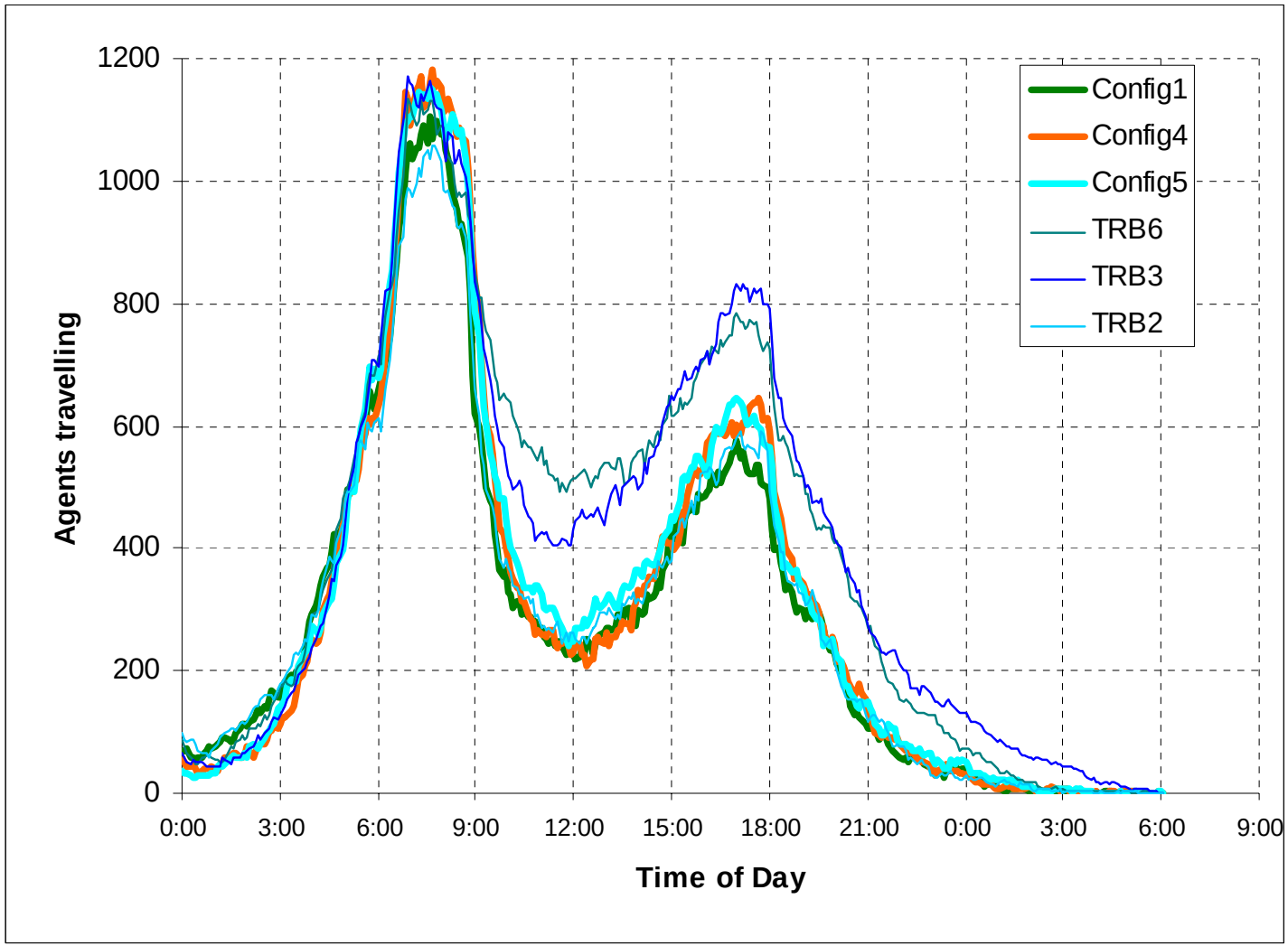
Spread of knowledge 500



Shifts in distance and duration of trip



Shifts in time (and congestion)



Summary of effects

Initial social network
- Only one tested

Information exchange
- Highly efficient (location change)

RePlanning
- Location choice raises trip distance, travel time

Social network evolution
- Topology does not evolve dramatically
- Geography does
- Link removal isolates immobile agents (no other social process)

Scoring
- Biggest effect with evolving network

Work to do: validation

Ensemble to discern which effects are significantly different between scenarios

Scaling versus universal phenomena:

- Other initial social networks
- Population/facility density
- World size

Effect of link removal algorithms in evolving networks

Effect of memory of knowledge and criteria for knowledge sharing

Directed social networks?

Work to do: experiments

Utility feedback, e.g.:

Ui = Ui' + U(J), J== ego net

Ui = Ui' + β TimeF2F

Ui = Ui' + β Num_NotFriends, $\beta < 0$

Social process feedbacks, e.g.:

Triad closure, preferential attachment, homophily index

Constrained relationship contexts, e.g.:

Average % friendships visited F2F in a day

Households and other social networks

Enforce facility capacities

Ride sharing utility and alternative transportation modes

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Alternatives to Utility-Maximizing

Rule-based decisions:

- If A does this, B does that
- Schelling

Satisficing:

- Strategy OK if utility exceeds average for group

Punishment, Altruism, etc.

- (Could possibly be incorporated into utility maximization)

Run summaries

	Avg. Trip Distance	Avg. Best Score	Avg friends score	AvgNFriends at leisure	Score-AvgFriend Score	AvgTripDuration	Trip Speed (km/h)
1	9450	165		0.1	165	1054	32.3
7	11250	166		0.1	159	1048	38.6
2	9460	181	20	0.2	161	1070	31.8
3	12720	184	28	0.3	156	1459	31.4
4	11220	165		0.1	165	1112	36.3
5	11300	164		2.2	164	1150	35.4
6	11700	294	136	2.9	158	1454	29.0