

Dynamics in Organizational Problem Solving and the Leveraging of Social Capital: An ABM Perspective

A Dissertation Defense

by

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Collective Intelligence for Problem Solving



WIKIPEDIA
The Free Encyclopedia



mozilla
Firefox

Can we mimic the success within an organization?



VS



Organizational Problem Solving

Exploitation

- Improve existing solutions
- Accelerate knowledge dissemination



Exploration

- Search for better solutions
- Preserve knowledge diversity

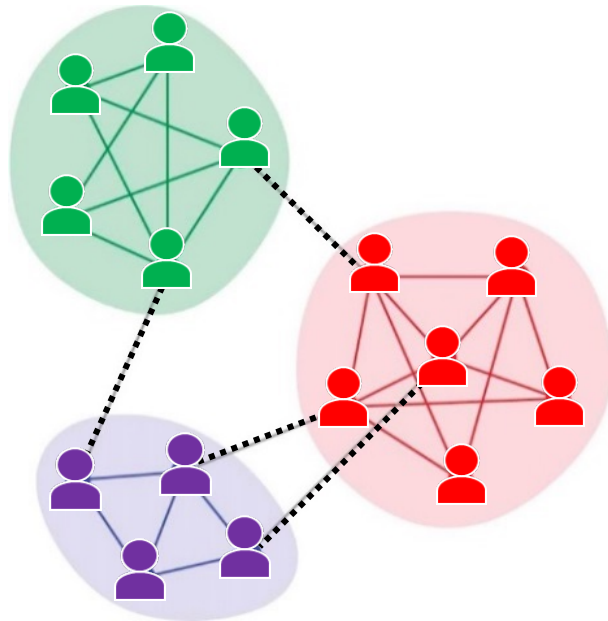
Organizations

- Resource constraints (budget, people)
- Performance pressure (time)

学而不思则罔，思而不学则殆。
——孔子·《论语·为政》

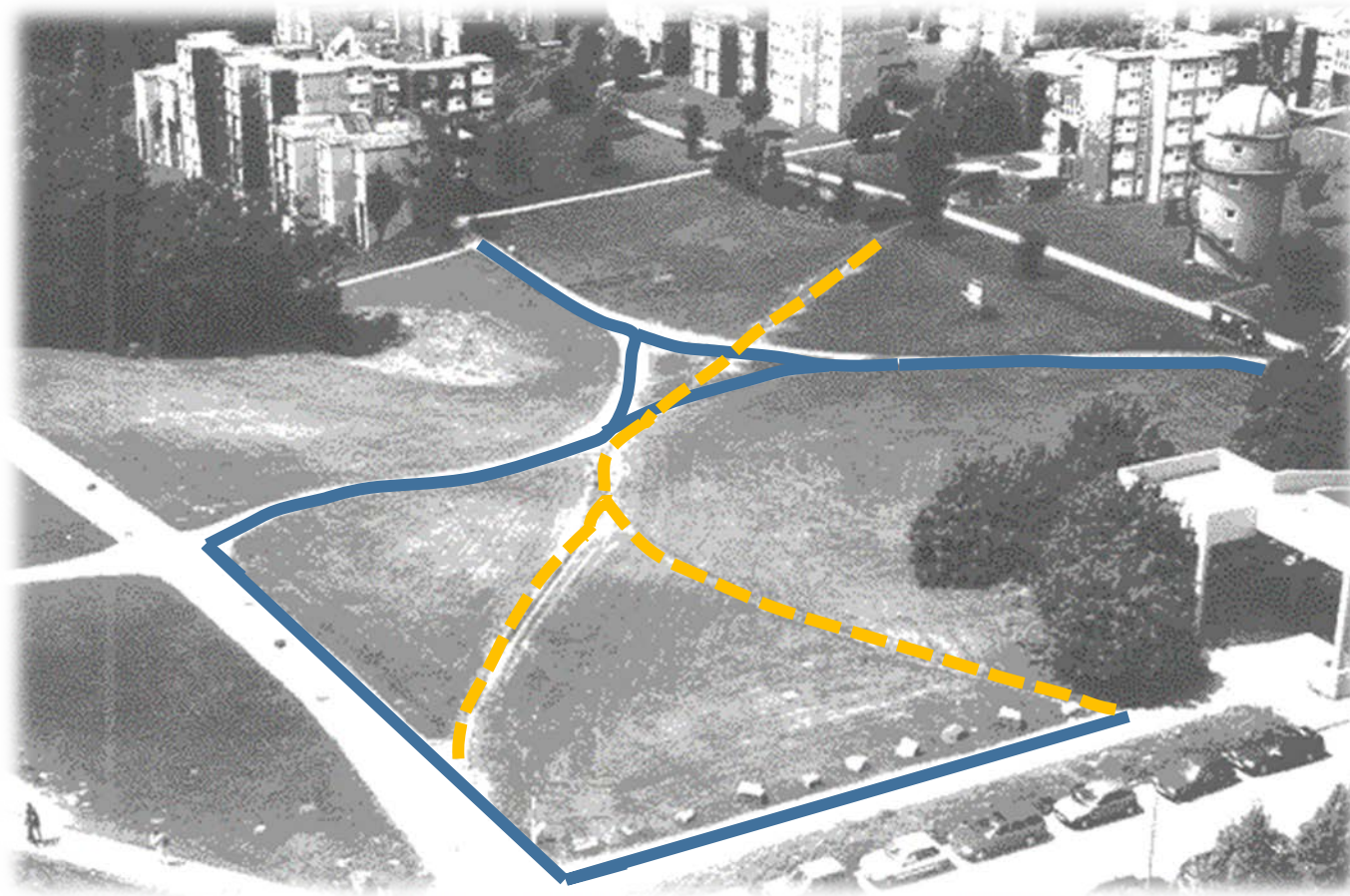
Organizational Structure as a lever

- Semi-isolated groups (Fang et al., 2010)



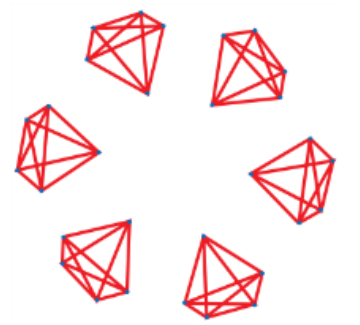
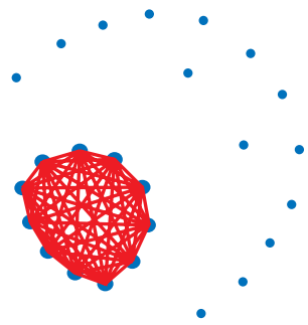
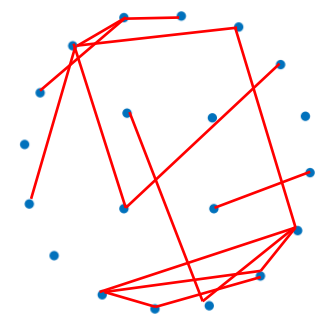
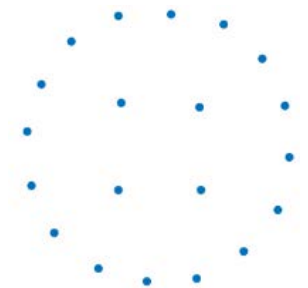
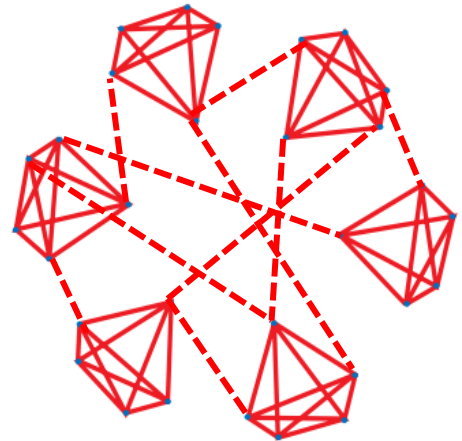
“It’s time to call in other people who don’t know more but are just different.”

Do people always follow structure?

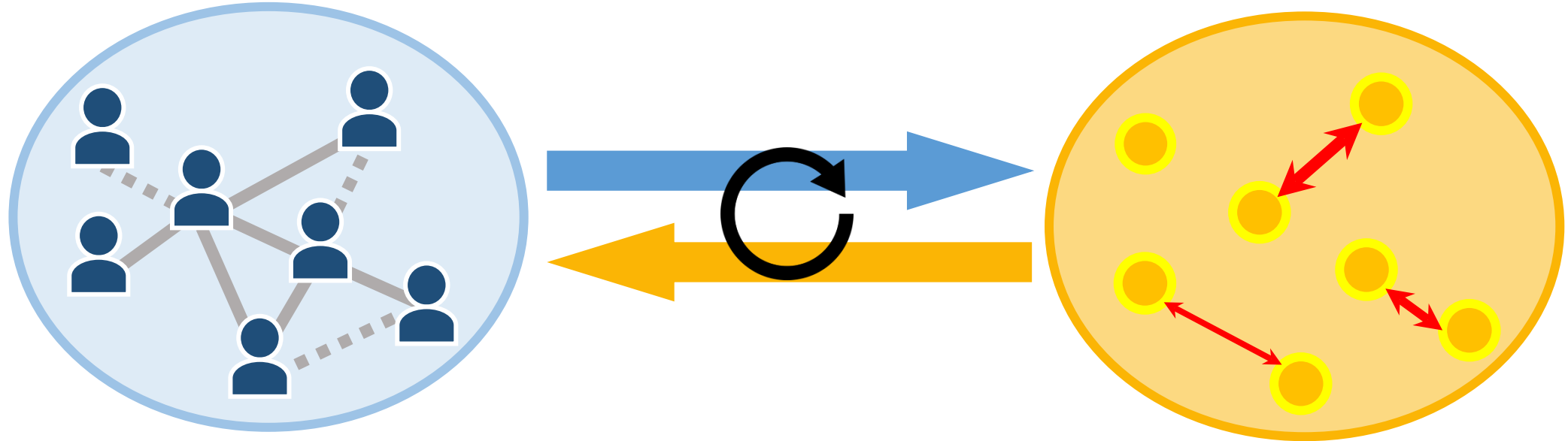


Helbing, D., Keltsch, J., & Molnar, P. (1997). Modelling the evolution of human trail systems. *Nature*, 388(6637), 47-50.
Figure 1: Between the straight, paved ways on the university campus in Stuttgart-Vaihingen a trail system has evolved.

I Wish...

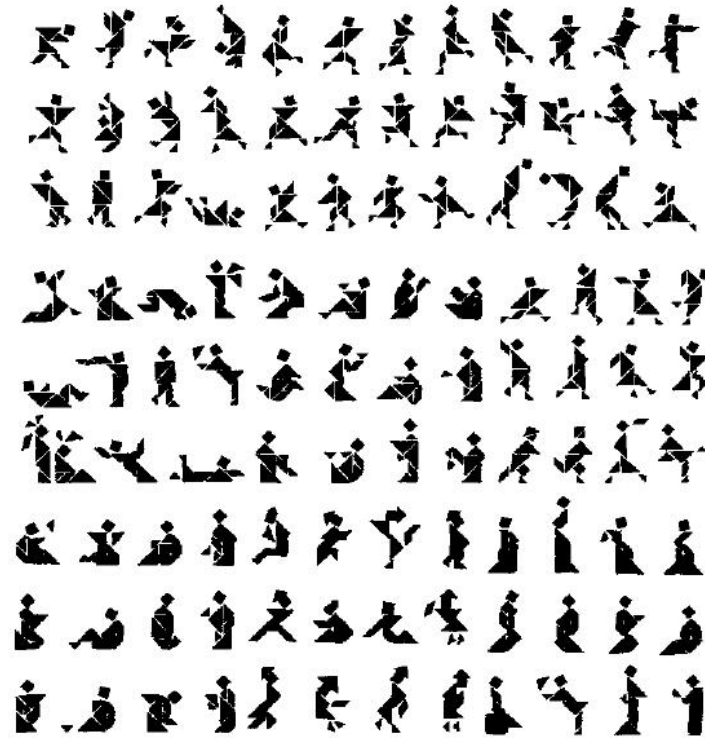
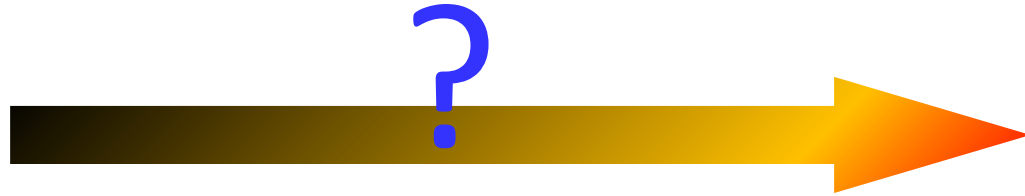
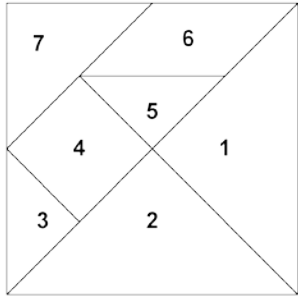


Research Question

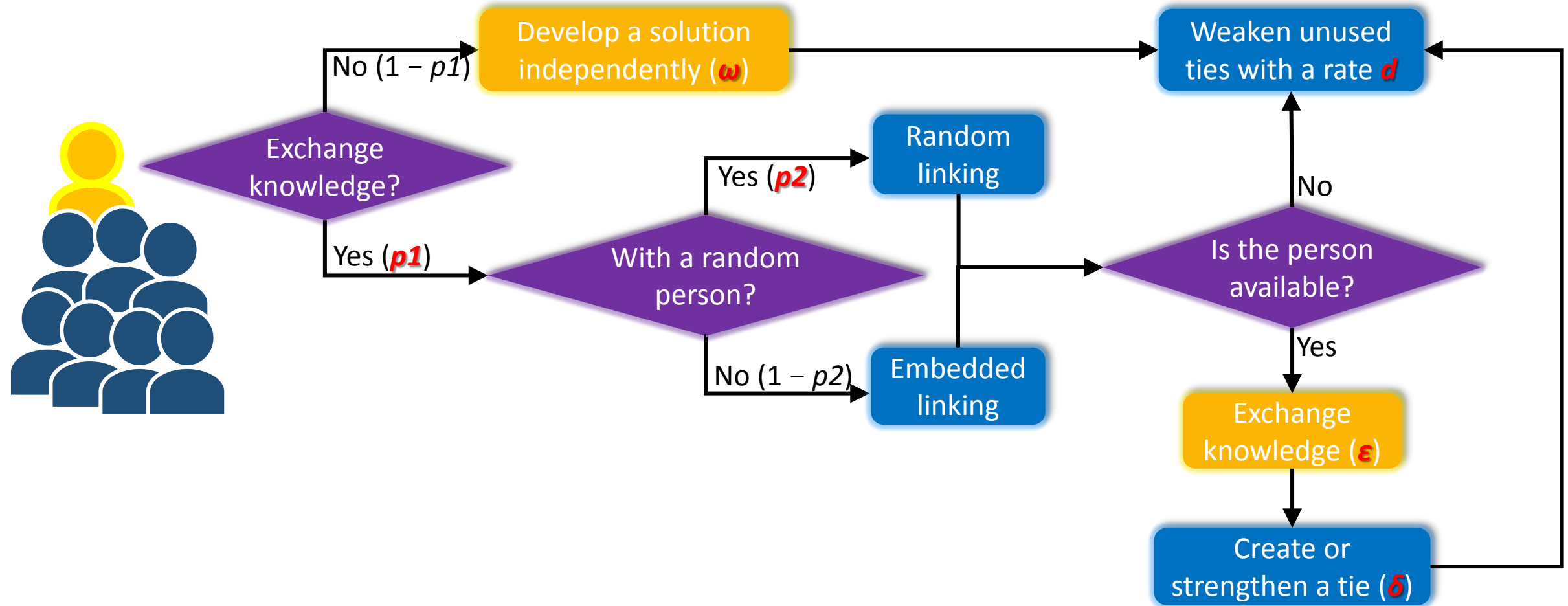


Given the **coevolution**, how would individual members' **autonomous** problem-solving behaviors **collectively** impact the organization's problem-solving performance?

Research Method – Agent-based Modeling



Agent-based Modeling – computer algorithm



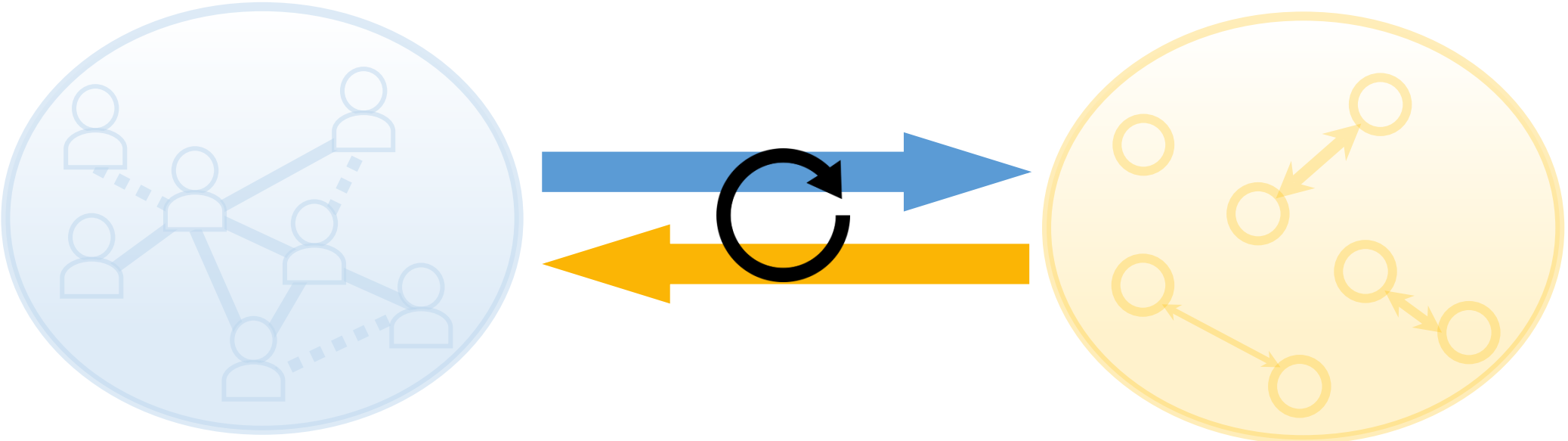
Agent-based Modeling – Java code

```
216
217
218  /**
219   * Both learn from the difference, even if one's current score is higher than the other's
220   * If the error is greater than zero, use it as the probability of dissimilar bits being mis
221   * NOTE - error is only introduced for dissimilar bits. So the more similar two solution are
222   * @param target
223   * @param space
224   * @param time
225   */
226  public void knowledgeExchange(OrgMember supPerformer, OrgMember infPerformer){
227      //Parameters params = RunEnvironment.getInstance().getParameters();
228      /**
229       * This parameter predefines the probability of error when the recipient estimates each
230       */
231      double err = Param.learnErr;
232      double reinforce = Param.wtGain;
233      double decayPower = Param.decayRate;
234
235      supPerformer.setIdle(false);
236      infPerformer.setIdle(false);
237      int solnLength = this.soln.length;
238      double bandwidth = 0.;
239
240      CustomTie sTie = (CustomTie) sNet.getEdge(supPerformer, infPerformer);
241      int s_index = Integer.parseInt(supPerformer.getID()) - 1;
242      int i_index = Integer.parseInt(infPerformer.getID()) - 1;
243      double wtAdd = reinforce; //the new weight should be at least 1*reinforceValue
244      if(sTie == null){
245          sTie = (CustomTie) sNet.addEdge(supPerformer, infPerformer, reinforce);
246          sTie.addEvent(currentTick);
247      }
248      else{
249          double oldWeight = sTie.getWeight();
250          sTie.addEvent(currentTick);
251          wtAdd = sTie.wtUpdate(currentTick, decayPower, reinforce) - oldWeight;
252      }
253      TieWtSumArray[s_index] += wtAdd;
```

Outline

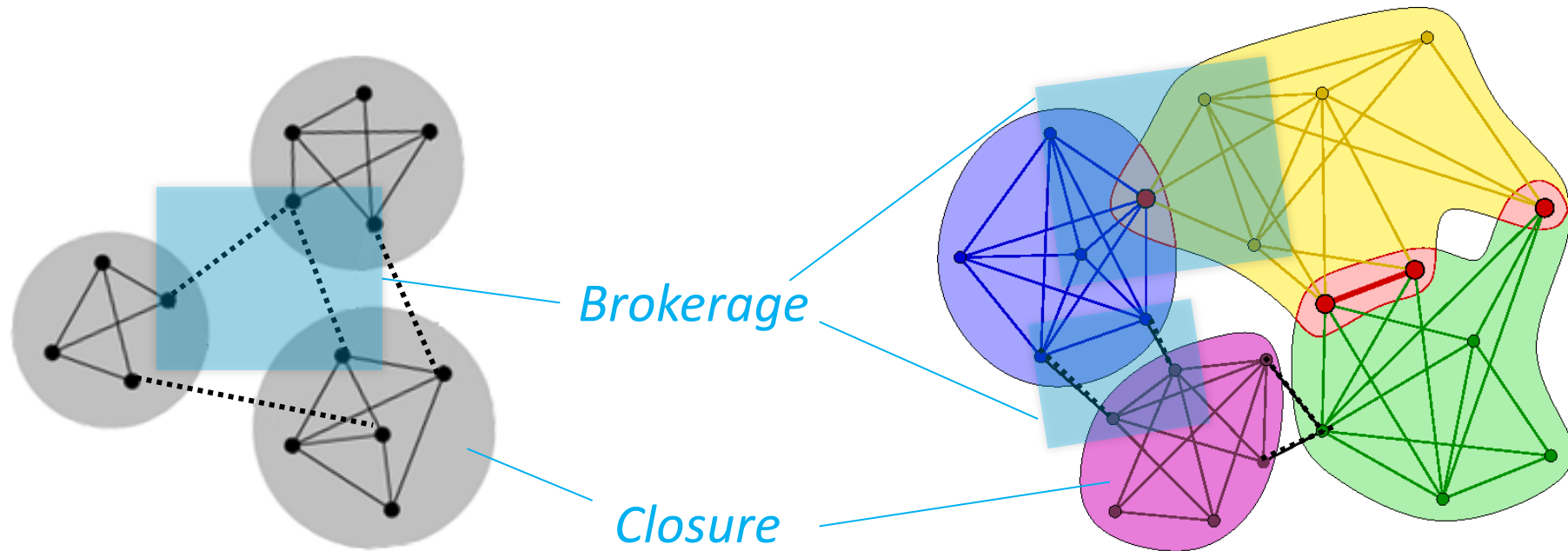
- NetStruggler
 - OrgMember
 - sNet: ContextJungNetw
 - currentTick: int
 - maxUnitTieWeight: dou
 - intervalDist: Map<Integ
 - TieWtSumArray: double
 - myID: String
 - localConstraint: double
 - soln: int[]
 - cur_score: double
 - new_soln: int[]
 - new_score: double
 - activityRate: double
 - localInterTime: int
 - totalInterTime: int
 - idle: boolean
 - interaction_type: int
 - initiateTime(): void
 - updateMaxUnitWgt(dou
 - getCurrentTime(): int
 - OrgMember(int, int[], d
 - setIntrType(int): void
 - getActivityRate(): doubl
 - getID(): String
 - setScore(double): void
 - getScore(): double
 - getSolution(): int[]
 - getPoint(): int
 - binToInt(int[]): int
 - solnUpdate(): void
 - isIdle(): boolean
 - setIdle(boolean): void
 - getIntrType(): int
 - knowledgeExchange(Or
 - selfLearn(): void

What should be modelled?

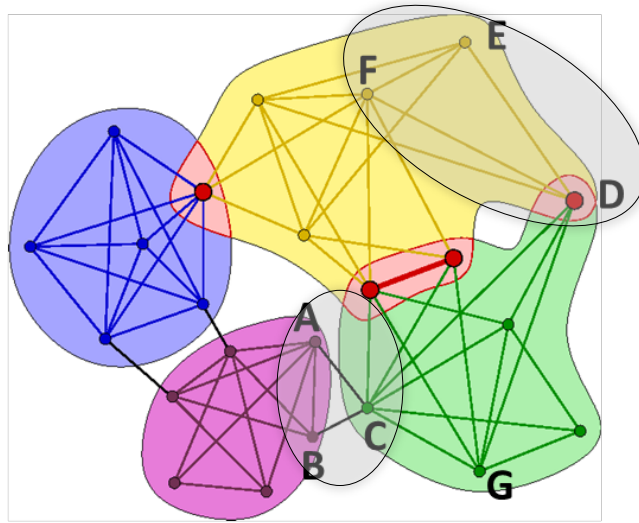


- Theory of Complex Adaptive Systems (Holland, 1976)
- An *iterative micro-macro feedback loop* can be maintained through three mechanisms: interaction, variation, and selection

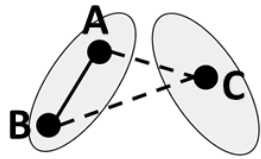
Macro Structure – A Hybrid Macro Network



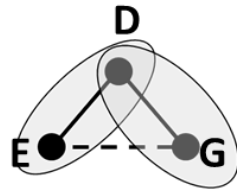
Network Topology



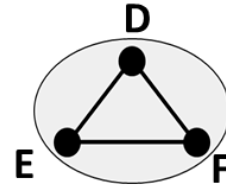
Triads



Bridge triad (two bridges)

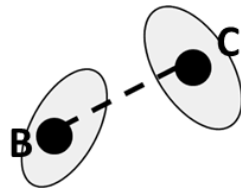


Bridge triad (one bridge)

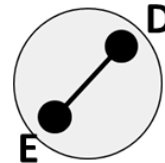


Bond triad (no bridges)

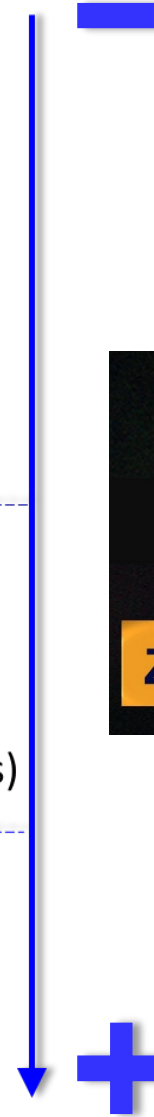
Dyads



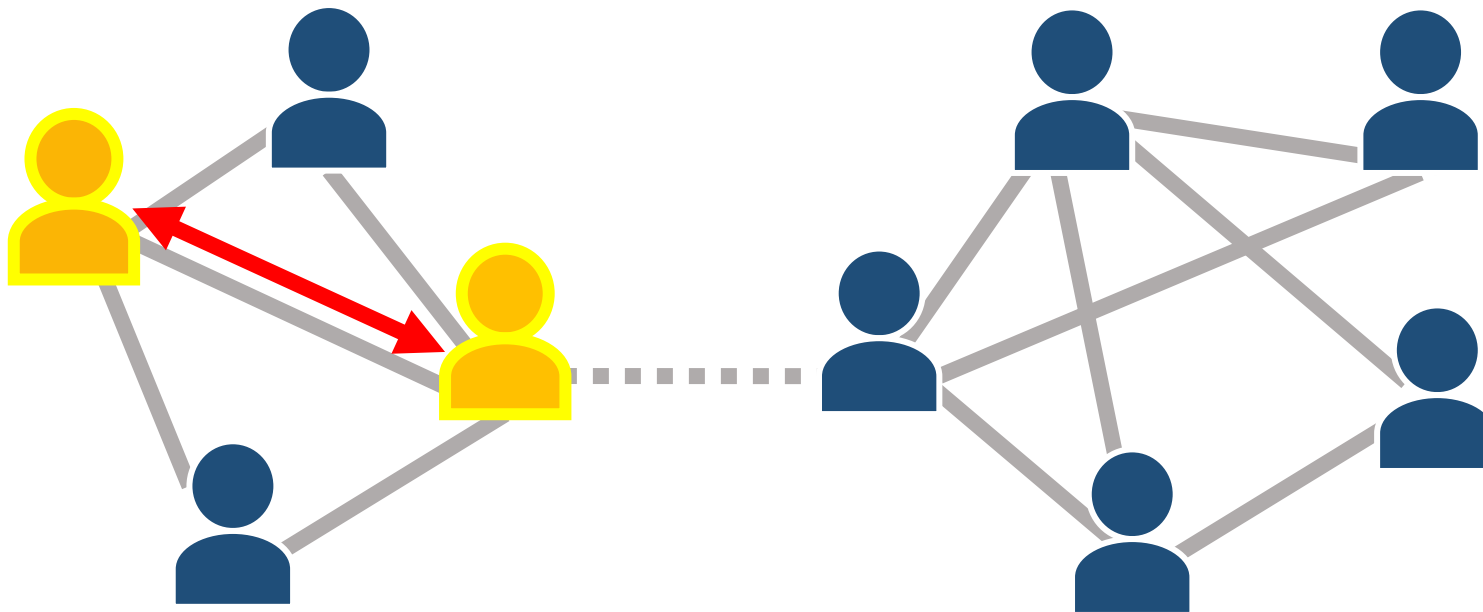
Bridge



Bond



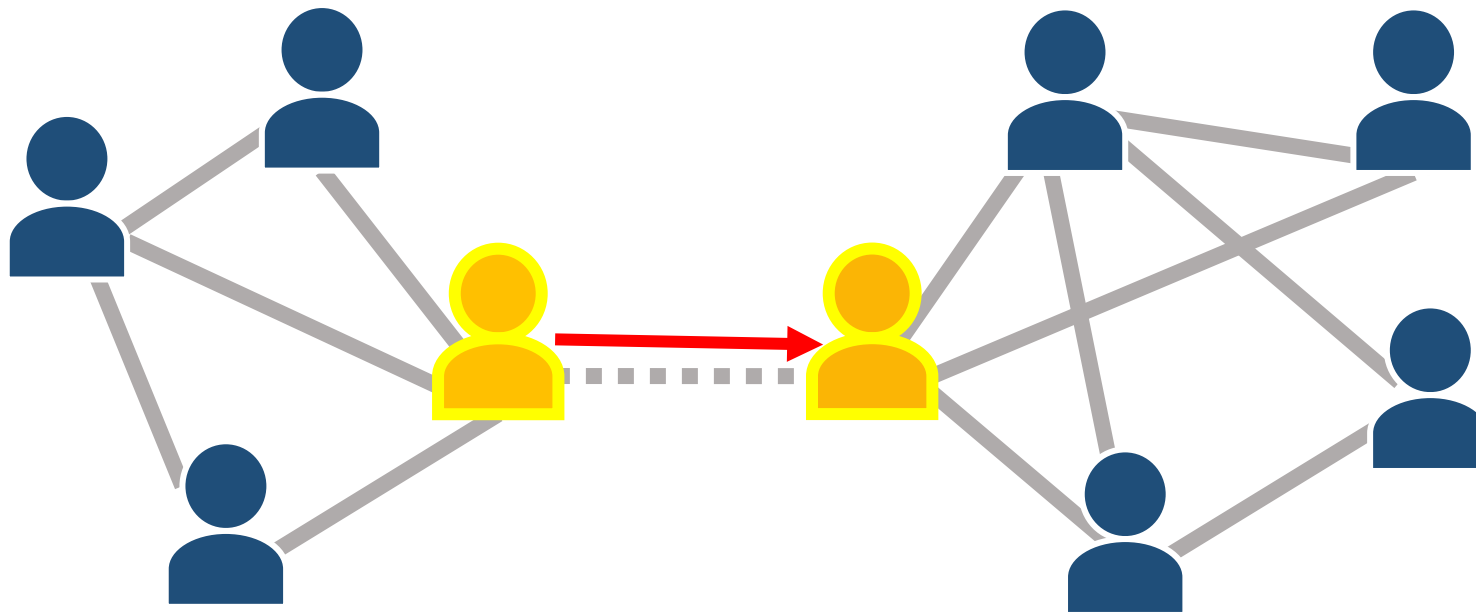
Micro Behavior – Leveraging Social Capital



Bonding

- Exchange knowledge with someone inside the same closure structure
- Create or strengthen a bond

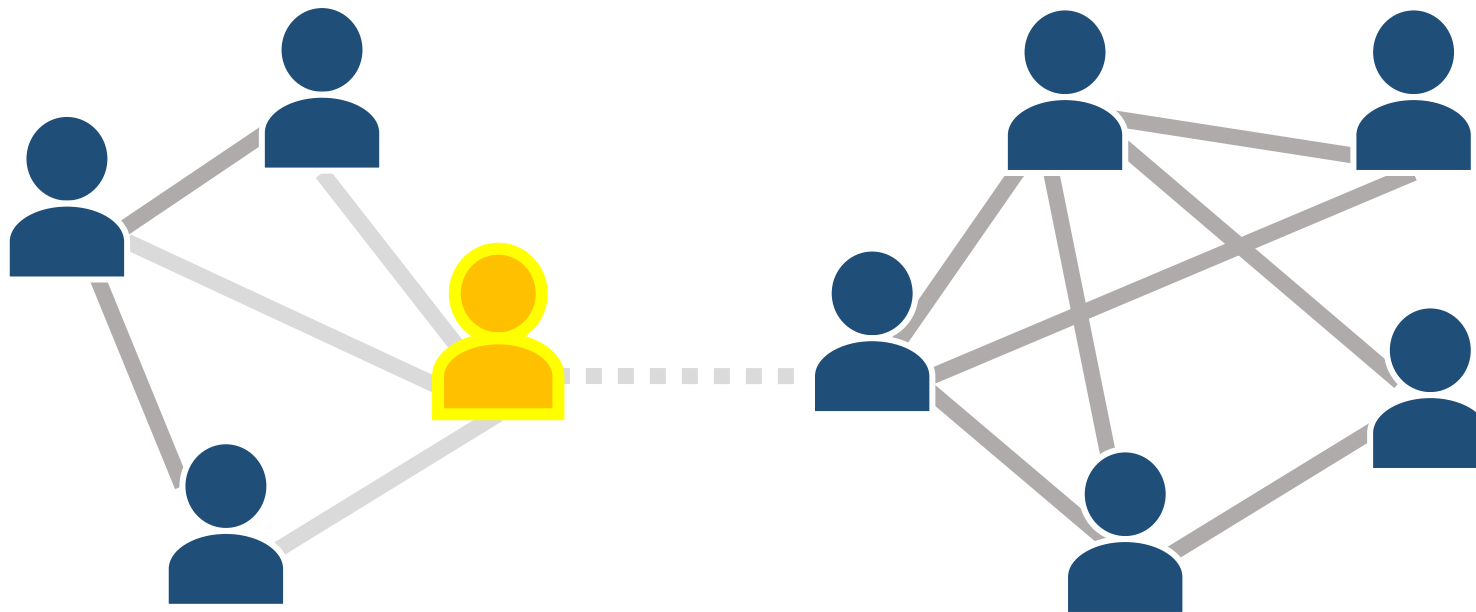
Micro Behavior – Leveraging Social Capital



Bridging

- Exchange knowledge with someone from outside the closure structure
- Create or strengthen a bridge

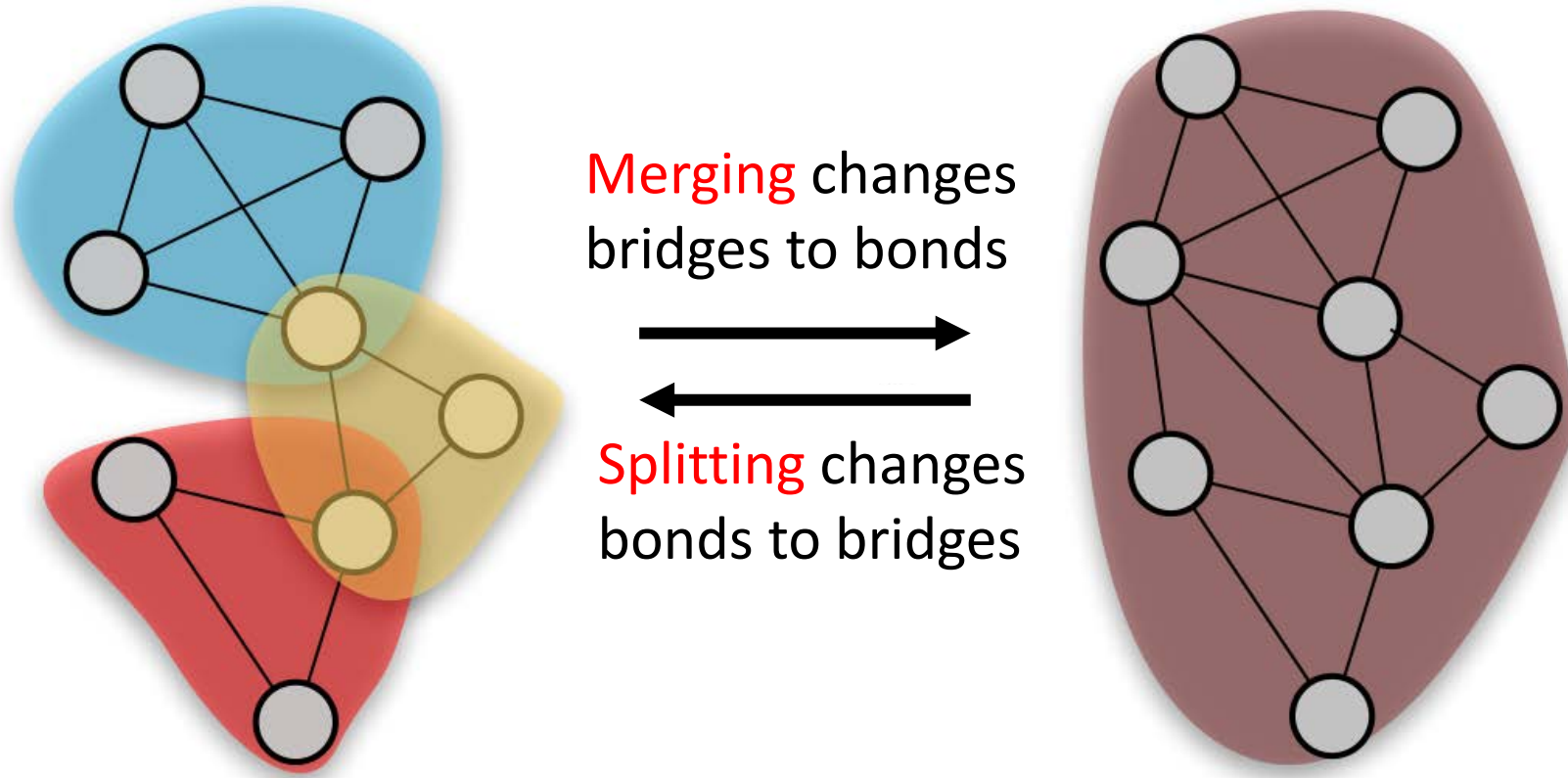
Micro Behavior – Leveraging Social Capital



No use of social capital

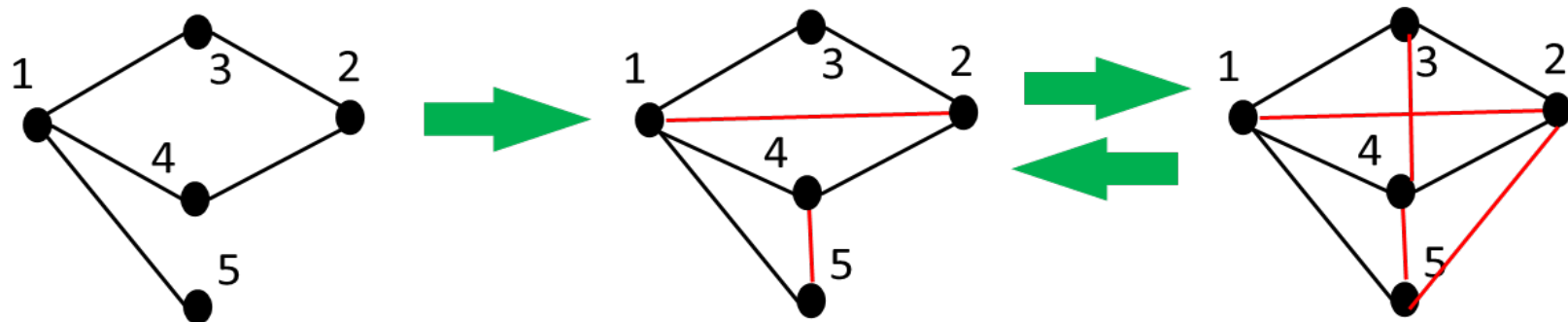
- No knowledge exchange; independent knowledge creation
- All connections decay

How to model bonding and bridging in a dynamic network?



Embedded Knowledge Exchange

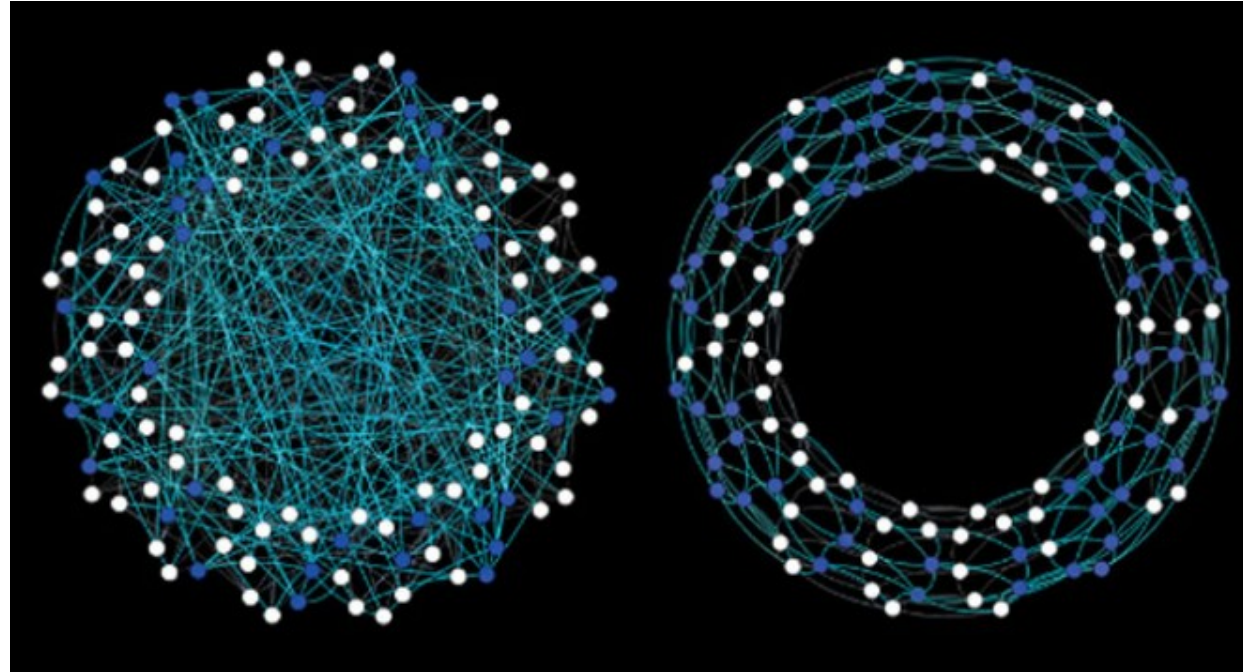
- Two agents interact based on triad closure
- Generate and maintain dense areas (closure)
- Cover bonding behavior



Local Network Constraint $LNC_{ij} = (\tilde{w}_{ij} + \sum_q \tilde{w}_{iq} \tilde{w}_{qj})^2, i \neq q \neq j$

Random Knowledge exchange

- Two agents interact randomly
- Escape dense areas
- Cover bridging behavior

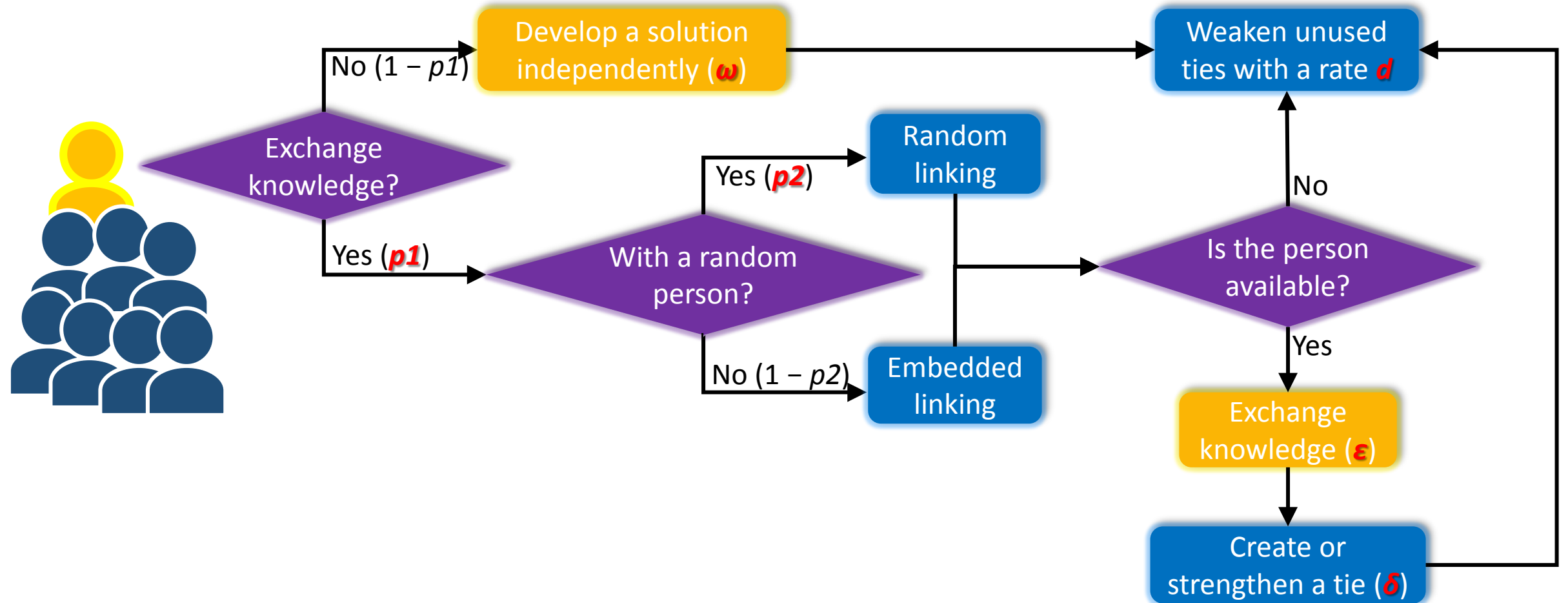


有意栽花花不发，无心插柳柳成荫。
——清·周希陶·《增广贤文》

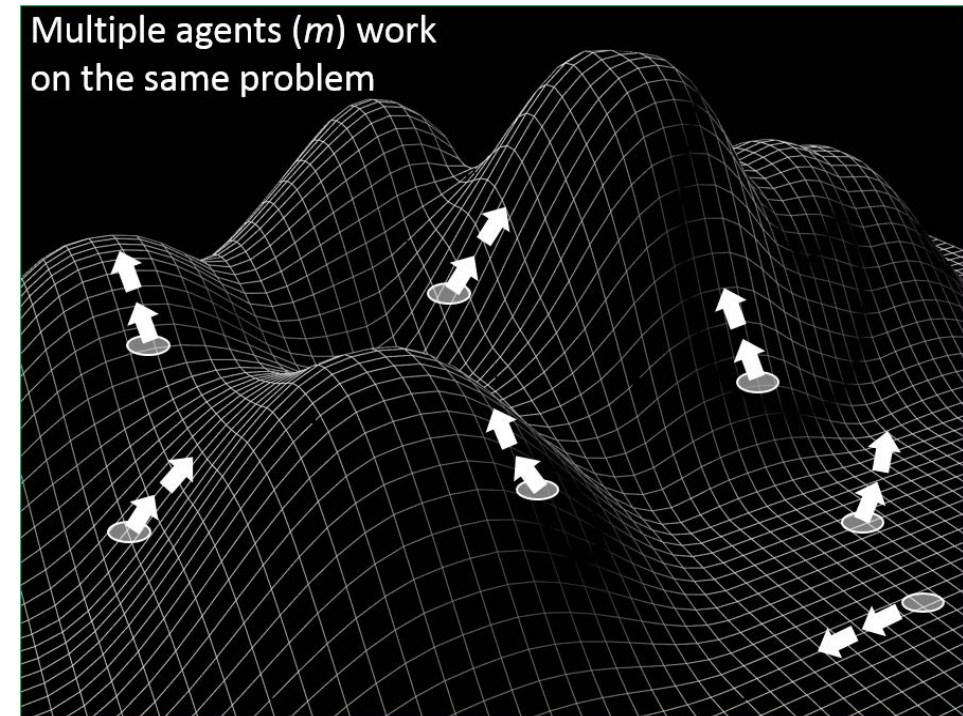
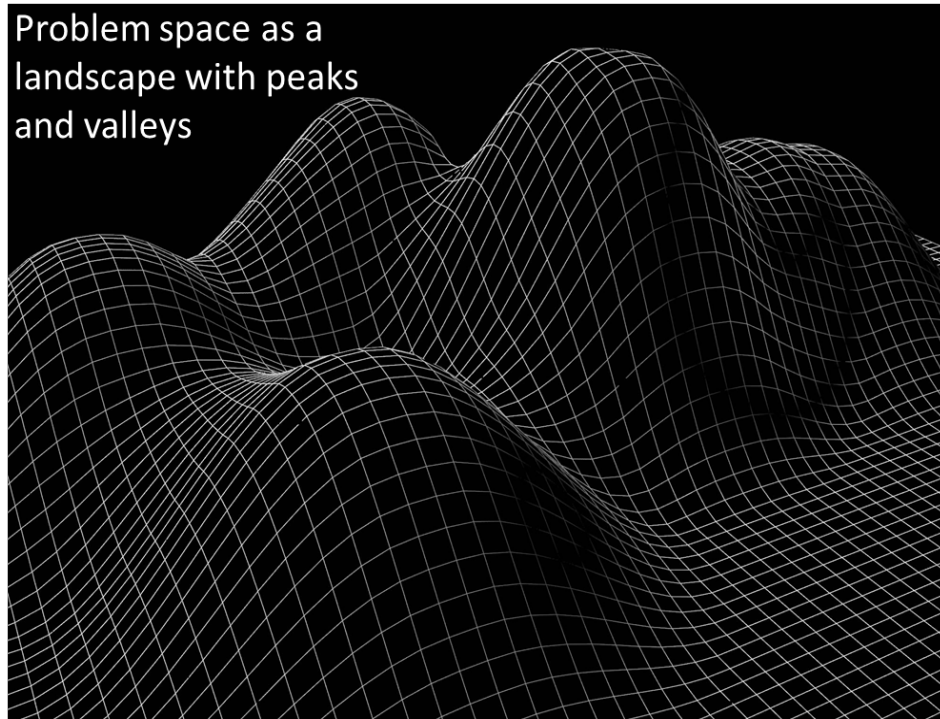
The Model: A Complex Adaptive System (CAS)

CAS element	Implementation
The system	An organization
Agents	Organizational members
Macro structure	A macro interaction network emerging from interpersonal knowledge exchanges (including no exchange)
Micro interactions	Random and embedded knowledge exchanges
<u>Variation</u>	New bridges and open triads created by <u>random knowledge exchanges</u>
<u>Selection</u>	Mutual reinforcement of closure structures and <u>embedded knowledge exchanges</u>

Simulation Process



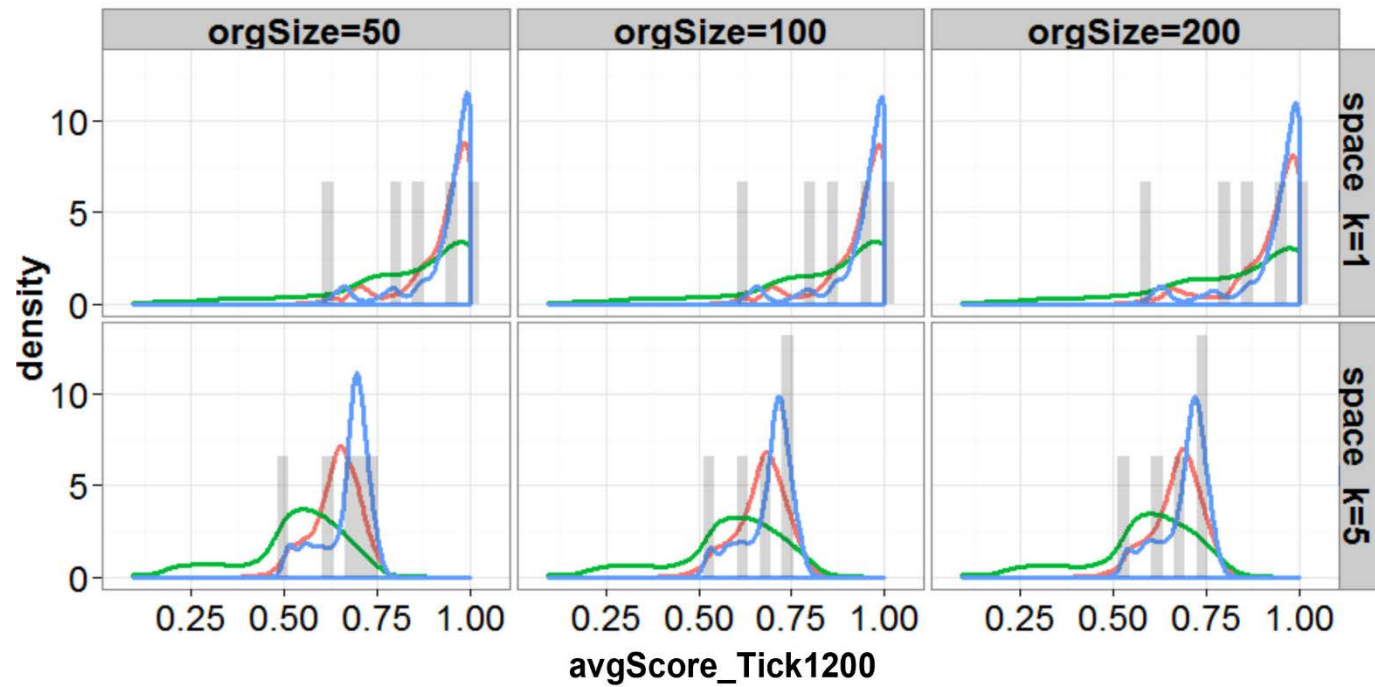
Modeling Organizational Problem Solving



Implication: which behavior is needed?



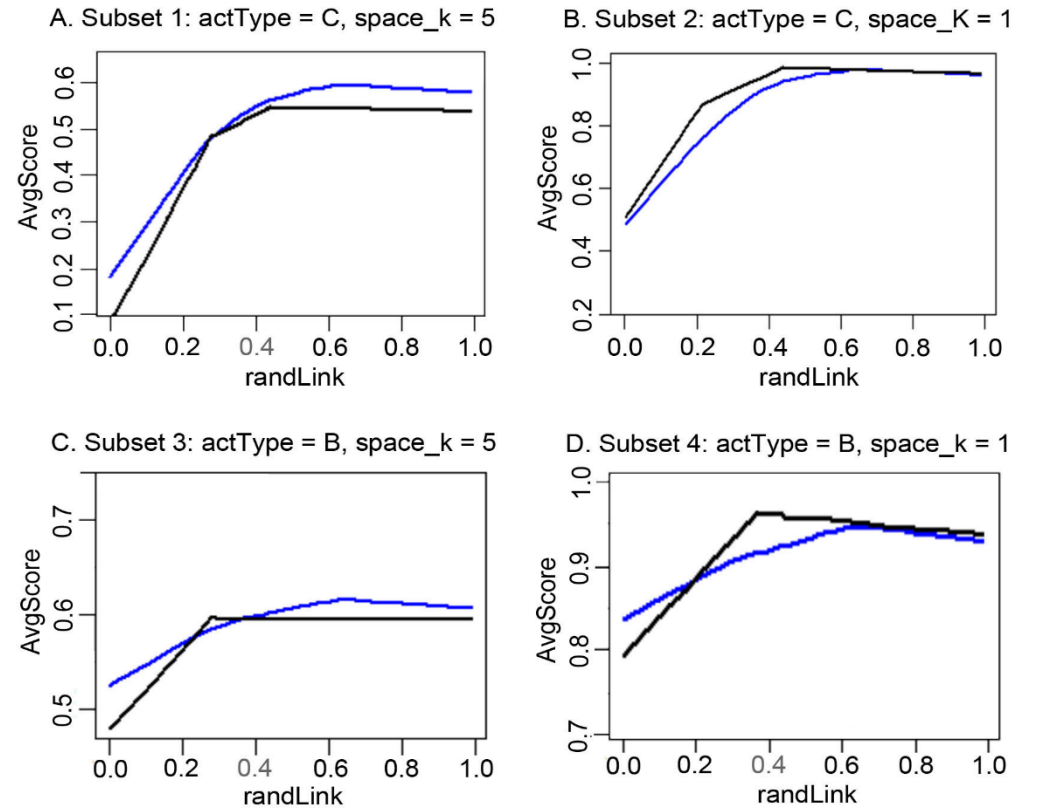
Related model parameters: individual propensities [\$p_1, p_2\$](#)



actType=A
 actType=B
 actType=C
 actType=D

Model Parameter: $p1$

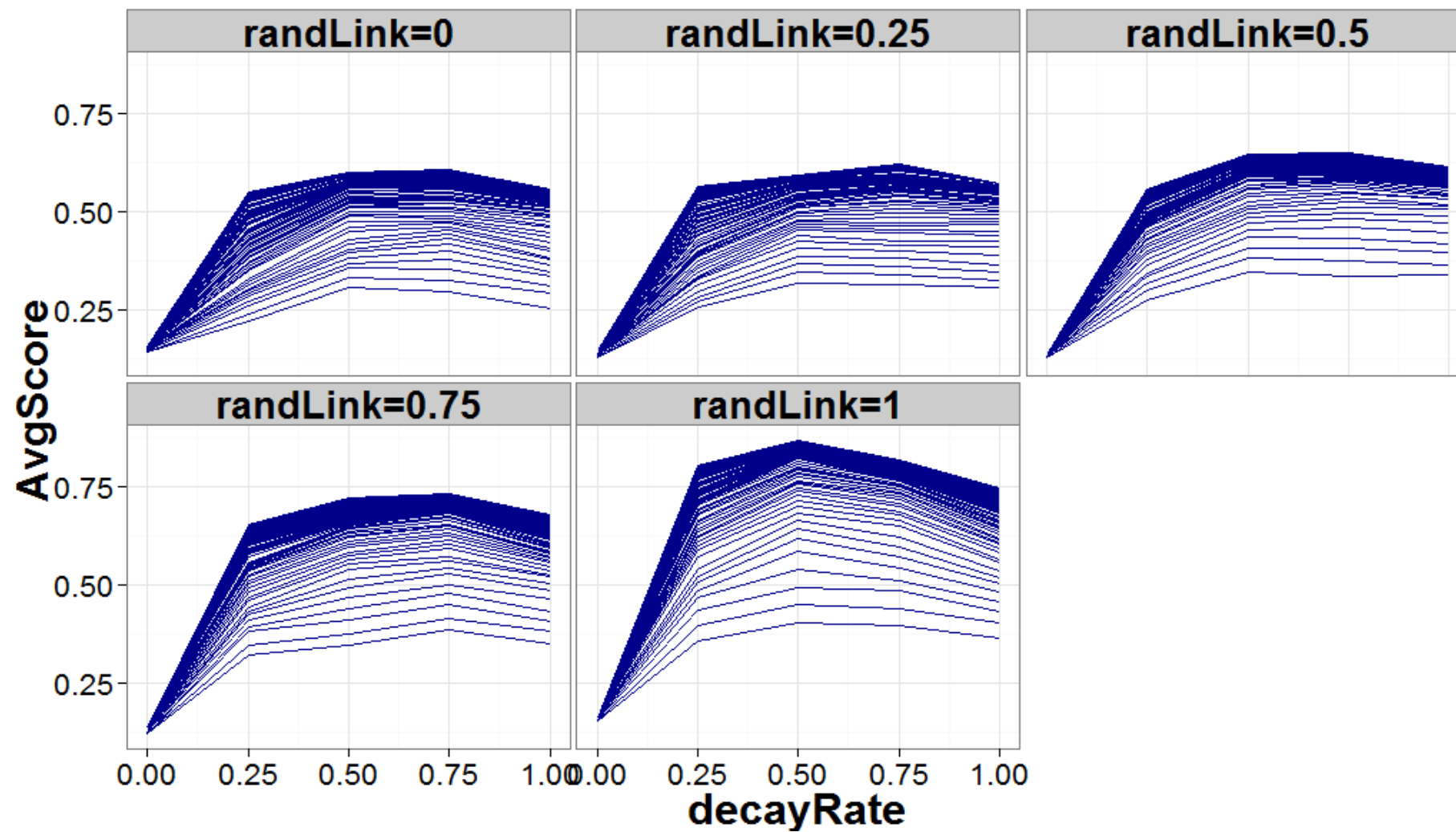
Model Parameter: $p2$



Implication: trapped in your own net?



Related model parameter: tie decay rate δ

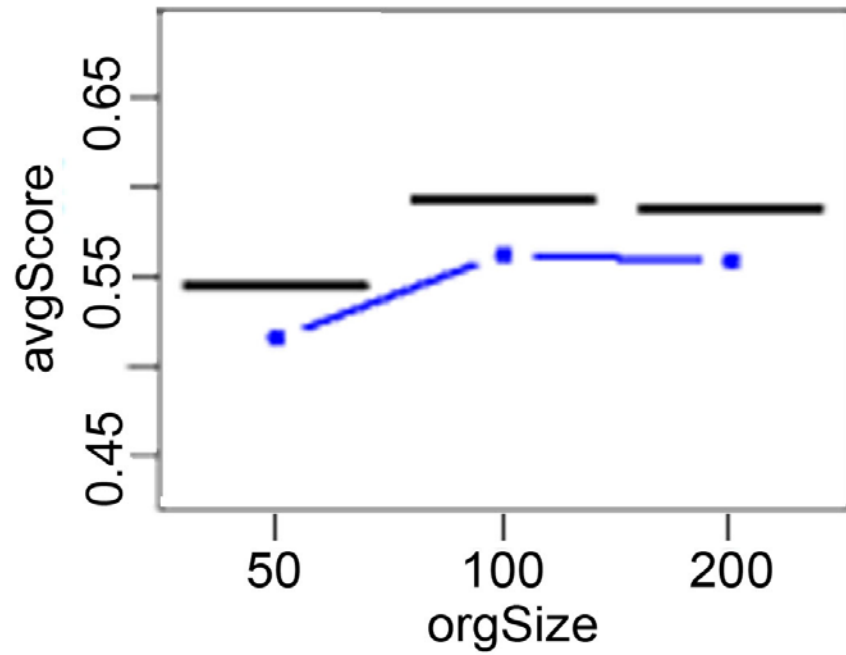


Implication: an optimal organization size?

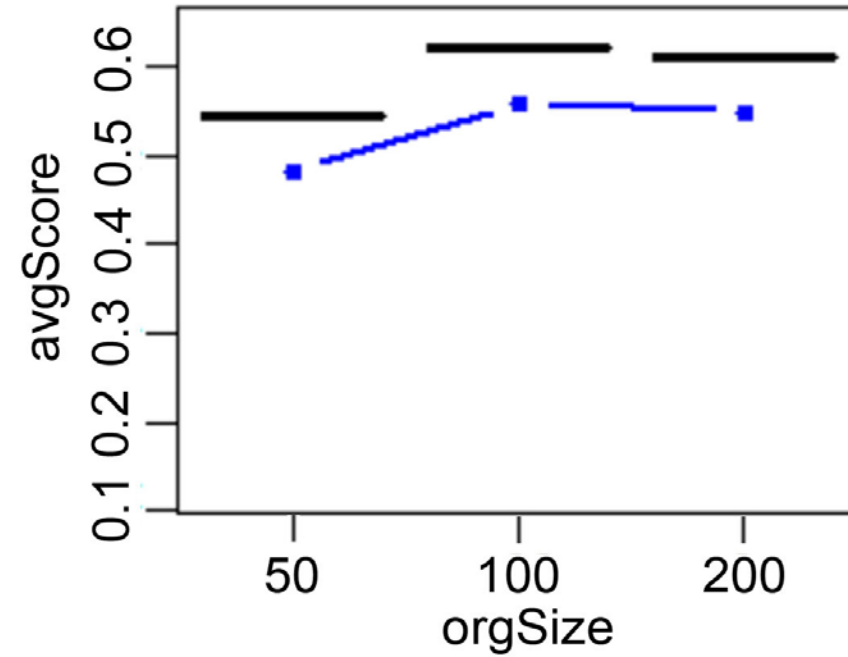


Related model parameter: organization size m

A. Subset 1: actType = B, space_k = 5



B. Subset 2: actType = C, space_k = 5



Simulation Experiments

- Latin Hypercube Design for sampling primary model parameters
 - 300 design points (experimental conditions)
- Crossed design for testing all model inputs
 - 1st crossed design: 7,200 design points
 - 2nd crossed design: 3,000 design points
- Each design point has 300 replicate runs
- Each simulation run lasts for 1000 or 1200 steps
- Extreme condition tests
 - 80 design points, each with 50 replicate runs

Contribution

Research area	Specific issue	Contribution of the current study
Organizational ambidexterity	<p><i>Ignorance of regular organizational members</i></p> <ul style="list-style-type: none"> • Lack of cross-level research • Lack of research on the underlying micro-mechanisms of contextual ambidexterity 	<p><i>The collective power of regular organizational members investigated</i></p> <ul style="list-style-type: none"> • Link organizational performances to regular organizational members' characteristics that impact independent and collaborative problem solving • Provide a micro-level and informal structure-based demonstration of contextual ambidexterity
Organizational social capital	<p><i>Lack of an appropriate synthesis of various social capital sources</i></p> <ul style="list-style-type: none"> • Overemphasis on network positions • Assume network positions are antecedents to motivations and abilities 	<p><i>Multiple sources of social capital addressed</i></p> <ul style="list-style-type: none"> • Jointly consider individual members' opportunities, motivations, and abilities to utilize social capital • Separate individuals' motivations and abilities from their network positions
Organizational social networks	<p><i>Lack of an appropriate combination of agency and network structure</i></p> <ul style="list-style-type: none"> • Predominance of structure • A local perspective on agency • Insufficient research on the genesis and dynamics of networks 	<p><i>Structuration theory faithfully modeled</i></p> <ul style="list-style-type: none"> • Implement the iterative mutual impacts between agency and the global network • Model an emergent and dynamic network whose evolution is pushed by endogenous and exogenous (random) factors

Contribution: extended macro structure



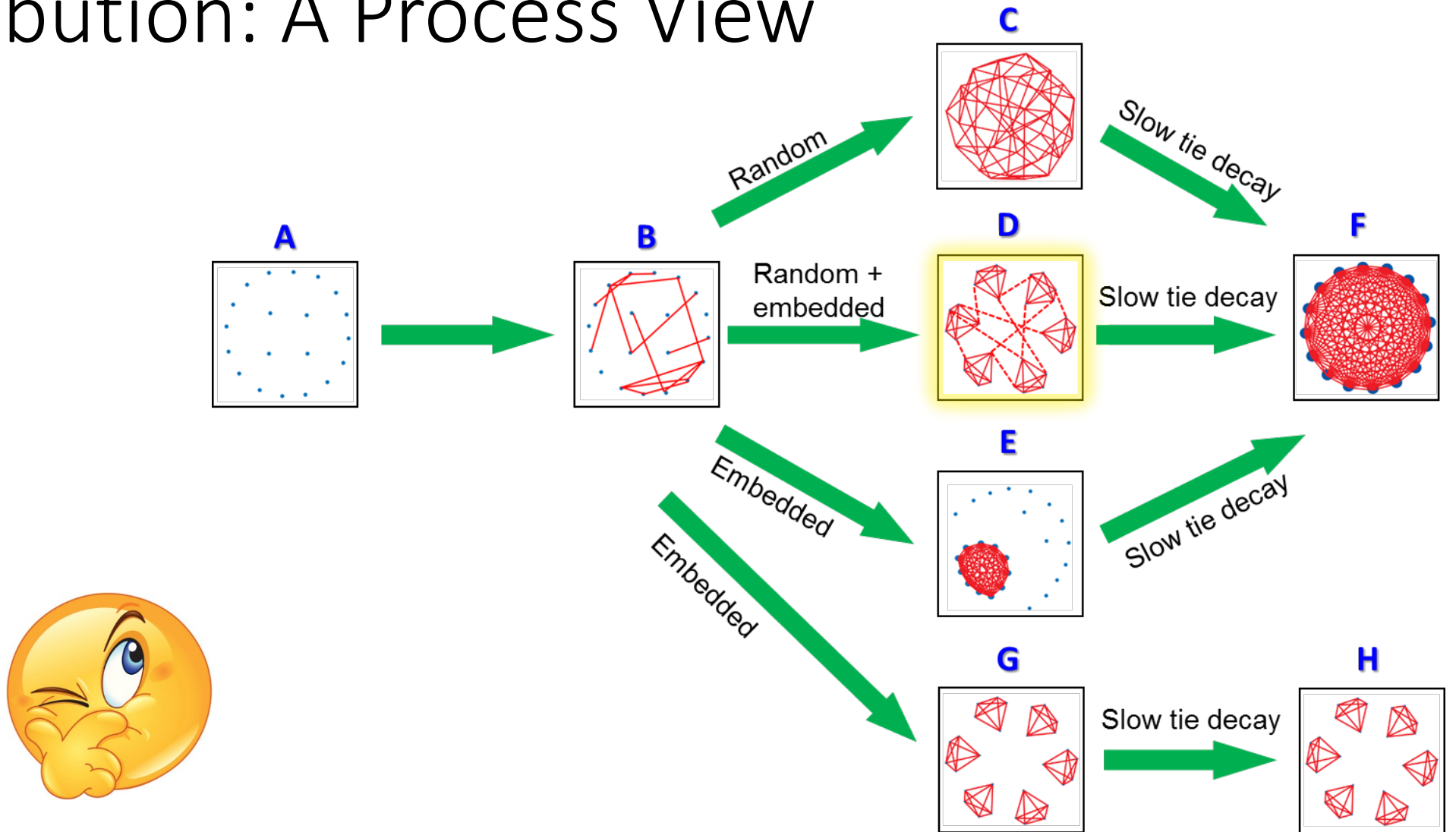
Previous studies

Determine interactions	Stable /static	Exogenous	Predefined	Memory-less
Coevolve with interactions	Changeable/dynamic	Endogenous	Emergent	Memory-loaded

Current study



Contribution: A Process View



Future Research

- Empirical testing of major findings
 - The influential factors and testable hypotheses revealed by the current study can shed light on and set up directions for future empirical studies.
- Application of the method
 - The methodology of the current study can be applied to other areas to help theorize dynamic phenomena
- Transfer of the model
 - The model developed in the current study can be modified and used for other CAS or micro-macro coevolution related topics.

Thank you!
Questions?