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Exploring Interaction Networks for Services Industry

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  - Dr. Brenda Dietrich, IBM T.J. Watson Research Center.
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- Open Collaboration Research (OCR) project between IBM Research and ISB.

- Source of Inspiration: “Serving the Services”, Brenda Dietrich and Terry Harrison, Operations Research and Management Science (ORMS).

Objective

- Present a *perspective* on the unique research domain that emerges in the context of *services*
- How it poses interesting challenges in established domains:
  - Supply Chain Management
  - (Social/Professional) Network Analysis
  - Economics and Game Theory
- Motivate via examples from the industry and ongoing research projects
- Cover modeling and algorithmic aspects of "*Service Interaction Networks*".

Overview

- Introduction [Vinayaka Pandit]
  - General
  - Leading to Service Interaction Networks
- Service Interaction Networks [Kameshwaran]
  - Case Studies
  - Problems
- Ranking in Service Interaction Networks [Kameshwaran]
- Team Dynamics in Service Interaction Networks [Vinayaka Pandit]
- Conclusion and Discussion [Vinayaka Pandit and Kameshwaran]

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Services and SSME

Definition

- Service is the application of competences (by the provider) for the benefit of the other (the client).
- The degree to which an exchange is a service is determined by the degree to which the unique client input and provider competence is essential to realize mutual benefit.

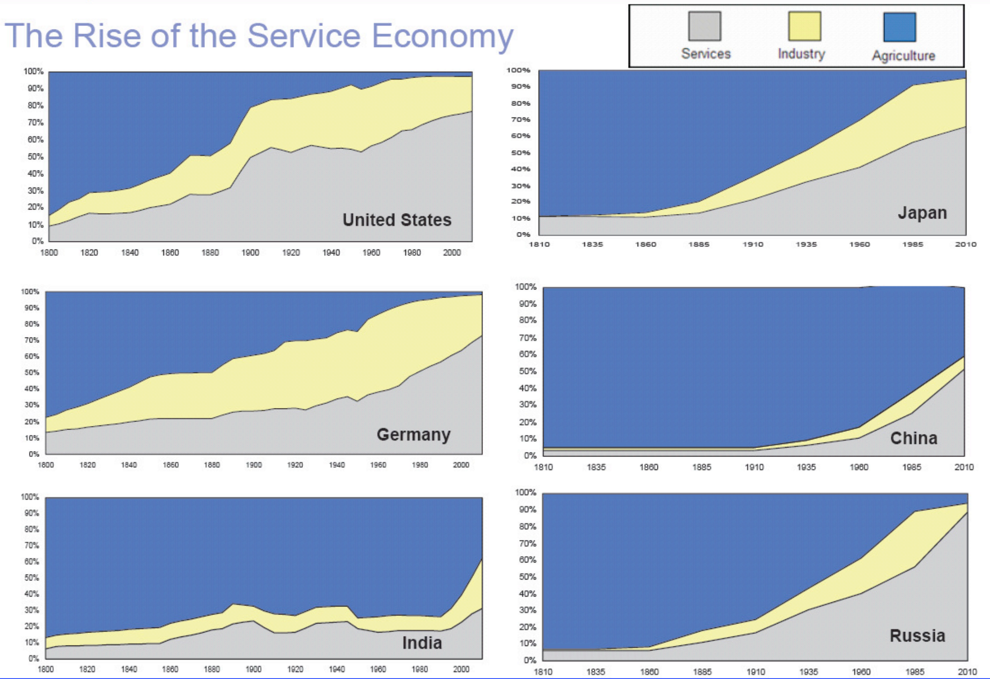
SSME

- Interdisciplinary effort that applies and extends concepts from traditional academic disciplines such as management science, mathematics, computer science, economics, and engineering for better understanding, and overall improvement of services.

Importance of Services and SSME

- Services accounted for 78.5% of US economy in 2007 compared to 20% in 1947.
- Story is no different in other developed economies.
- Largest growing segment even in developing economies like BRICS.
- Even then Services are delivered and analyzed in ad-hoc fashion rather than based on a principled and systematic approach!

The Rise of the Service Economy



Examples

- Web Services
- Banking, Finance, and Insurance Services
- Healthcare Services
- Post-sales services
- Consultancy Services
- Software Services
- IT-enabled Services

Some Observations

- Wide Range
  - Nature
  - Scale
  - Value
  - Skill-levels
  - Users: Vary from individuals to large businesses
- Highly dependent on people and their effectiveness!
  - At a *transactional* level in addition to the IP level
- When there is an underlying product or an asset
  - Same organization provides both product and service
  - They are different organizations
- A service itself could be “produced” or “orchestrated”

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The landscape is not new to CS

- Web Services
- Technology Services
  - Storage as a service
  - Software as a service
- Consultancy Services
  - Specific optimization/analytics for industrial application
  - Airline industry; CRM Analytics; and so on..

What has been our role?

- Web Services (Technology Enablers) (Standardization)
- Technology Services (Technology Enablers)
  - Storage as a service
  - Software as a service
- Consultancy Services (Specialists)
  - Specific optimization/analytics for industrial application
  - Airline industry; CRM Analytics; and so on..
- SOA (Technology Enablers) (Standardization)

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Relation to our discipline

- We have applied our knowledge and expertise
  - We have added value
  - We are respected for that
- But… What has it given back to our discipline?
  - New paradigms?
  - New models?
  - Yes, there are notable examples: Streaming!
- We hope to present a *perspective* of services that *may* enrich our discipline

Basis for our contention

- Contribution of Computer Science and Operations Research to
  - Manufacturing and Enterprise Resource Planning (MRP/ERP)
  - Analytics for Customer Relationship Management (CRM)
- While making great impact on industrial practice, they gave us
  - Celebrated concepts in Data Mining (Association Rule Mining)
  - Robust/stochastic network designing paradigms
  - Forecasting techniques
- So, what *is* the *perspective*?
  - While aspects of services to individuals is familiar to us, the *complexities and novelties* in *providing business services* is largely unexplored

Issue 1: Inventory

- Traditionally, a fundamental requirement in dealing with variations in demand, supply, and process yield
  - Difficult to think of a manufacturer who does not maintain inventories!
  - Inventory does not imply loss (with appropriate accounting for storage and time-shift in utilization).
- Consider a company which provides Software Services
  - Its market assessment says that 3000 Java programmers are needed in Q2
  - What should it do?
- Build a capacity of required programmers?
  - What if the demand does not materialize?
- Wait until demand materializes?
  - What is programmers are not available at the time?

Issue 1: Inventory

- What is the source of its dilemma?
  - Maintaining a bench (inventory) results in loss
  - Unmet demand results in revenue lost (to a competitor)
- What is it a result of?
  - Java programmers are needed exactly when there is need
  - That is, a service is produced almost simultaneously with the demand!
- What is the challenge?
  - Demand is uncertain
  - Demand is dependent on the action of other players
  - Demand sometimes depends on “external events” (Y2K programmers!)

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Issue 1: Technical Challenges

- New forecasting techniques that take into account
  - Sources of demand (traditional)
  - Actions of other players (how do we do it? Choices: Game theory, Information Retrieval with KM, …)
  - External events
- Assuming the above is reasonably solved,
  - What should be the inventory policy that achieves a tradeoff between bench cost and lost revenue?
  - Indirect means to alleviate the problem: commitment management, multiple service classes, pricing …

Issue 2: Analogue of bill of material

- What does a "unit of work" (a problem ticket or a new feature development) require?
  - How many people of what level of experience and skills?
  - Infrastructural and logistic requirements
  - There are always alternatives
  - In traditional manufacturing, these are known unambiguously.
- Technical challenges,
  - Given a number of instantiations of a similar kind of services, can we infer the different combinations of BOMs?
  - Suppose you need skill X and you have access to skill Y. From the historical data, can we assess the "transition cost"?
  - Using the above, can we generate (partly automated) new BOMs with implications on cost and time?

Issue 3: Machines Vs People

Machines	People
Fail (decisively; but, rarely). "crash" failures	Get bored frequently, but for short periods; Mainly "transient" failures
Will hardly ever outperform themselves!	When motivated and in congenial atmosphere, outperform themselves
Do not "learn" skills. No need to worry about "transitioning" to new roles	People learn new skills while doing projects. Have to plan for "transitions".
Interactions of different machines is as designed!	Interactions do differ from design and make positive/negative impacts
	Even in normal settings, people have "ramp-up" and "steady" states.
	Exogenous factors make people enter and exit the systems (unlike machines).

Issue 3: Machines Vs People

- Resource Management and Deployment
  - Team composition is critical (skill matching and compatibility)
  - Plan for identification and timing of “transitions”.
  - Planning for training people that accounts for
    - New Forecasting Techniques
    - Inventory policy
- Interactions and their analysis is key
  - Can we say if a proposed team will be “effective”?
  - Can we rank the people based on their connections and effectiveness?
  - Is the interaction among the people as desired by the service being delivered?
  - Current expertise of a person and expertise (collaborators from past) that he has access to?

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Issue 4: Processes!

- Human/semi-automated processes are the analogues of production processes in service delivery
  - Suffer from complicity unlike in the automated, mechanical setting!
  - “Easily” violated as compared to production settings.
- Process Analytics
  - What are the right metrics and measurements (non-intrusive) for processes?
  - How to identify true bottlenecks in the processes?
  - How to modify them for better operations efficiency and throughput?
  - How to map the different stages to different technological alternatives and choose optimal tradeoff?

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Other Challenges

- Formalizing the notion of, and protocols between "front stage" and "back stage" for wide class of services
  - Placing your order in a restaurant is front-stage activity
  - How your food reaches you is back-stage activity
  - Your experience (service quality) depends on both
- Will such a formalization help substantial part of back-stage avoid the simultaneous demand-consumption phenomena?
  - And thereby allow partial use of traditional inventory policies…
- Measuring Service Quality (and improving)
- Strategic and tactical planning of acquisition, training, and termination of resources
- Pricing Service Contracts

An Interlude: Service Innovation

- Involves the development of new procedure and concepts rather than new core technology
- Typically, involves accomplishing a frequent, and essential tasks (bank transactions) more efficiently either using new methods (Single Window Clearance!) or by exploiting technology (ATMs).
  - sometimes in user-friendly and less intrusive manner as well!
- Commonalities between product innovator and service innovator organizations [Nijssen et al.]
  - Strong commitment and substantial resource allocation.
  - High top management involvement [Apple (product), Li&Fung (service)]
  - Carefully align their culture and systems (and processes) to support innovation
  - Not the least, high quality R&D staff augmented with auxiliary resources.

An Interlude: Service Innovation

- Differences w.r.t. product innovation stems from specific characteristics of services
  - At times, innovation involves developing the pre-requisite for the service! (mobile banking)
  - Due to real-time nature, new services go hand in hand with modification to delivery processes and changes in front-stage employee's skills.
  - Therefore, interaction between service innovation and service delivery is innate, stronger, and critical as compared to new products.

- While front-stage's main goal is to satisfy customer needs and improve customer experience, the back-stage's main goal is overall operational efficiency and throughput!
  - This tension extends to service innovation as well

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An Interlude: Service Innovation

- "Willingness to cannibalize" (W2C) [Chandy and Tellis, Nijseen et al.],propensity for innovation, and radicalness of new products and services, are interrelated
  - W2C current sales
  - W2C prior investments
  - W2C organizational routines.

- Nijssen et al. have studied various aspects of W2C and innovation w.r.t. new services and products.

- Their major findings based on a survey of data from 1500 SMEs in the Netherlands is,
  - R&D strength has a stronger effect on radicalness in the context of new products than in new services.
  - W2C organizational routines has a stronger effect on propensity for innovation in the context of new services than in a new product.

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Example: Software Service

- Consider a software service firm
  - Say, it is providing maintenance service to a software product company
- How does the “process” work?
  - Users of the product lodge complaints on problems that occur.
  - The complaints reach the software service firm’s “INBOX”
  - A designated person reads the INBOX and based on the content of a complaint, forwards it to a suitable team.
  - The team leader, assigns a developer for the complaint, a reviewer for the solution approach, a code reviewer, a functionality tester, and a system tester.
  - Together, they are responsible for resolved the problem.
- What was the quality of a unit of work?
  - Perhaps the complaint lodger praised the solution
  - Perhaps, several future problems originated from the proposed solution (this is tracked as the developer has to cite the source of problem)
  - Based on these, a resolution can either be a success or a failure

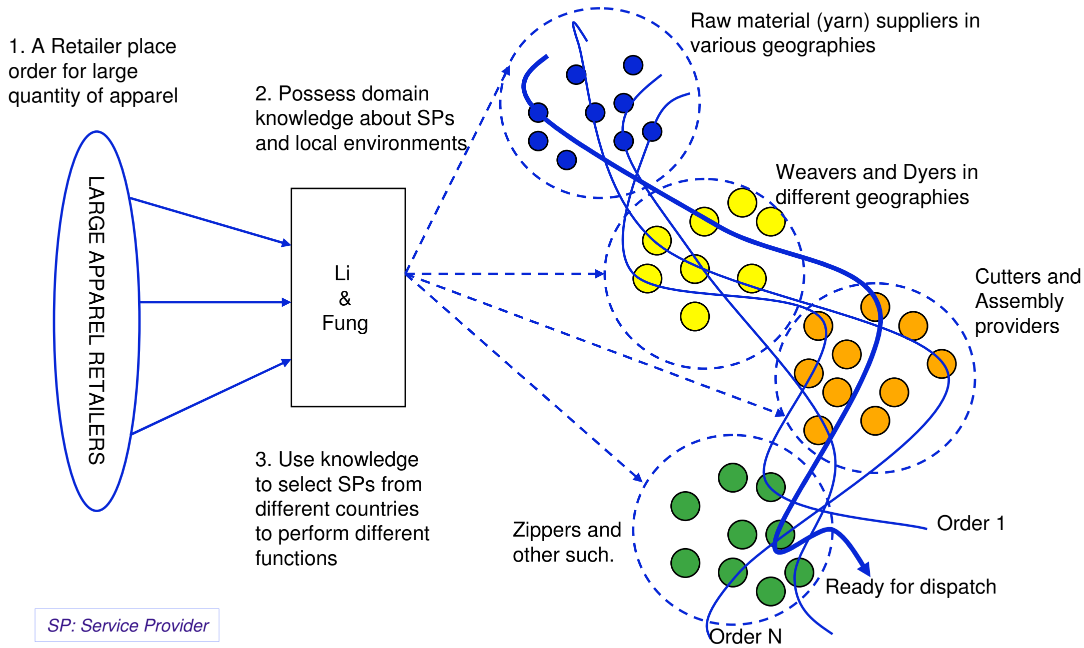
Example: Software Service

- Thousands of problem-tickets are resolved by the organization
- Typically, a person is involved in at least one resolution in a week
- The blame or the credit of a resolution is shared by all members
- How do we determine good combinations, how do identify and reward good performers, and how do we identify those who need training?

Example – Li and Fung (Service Supply Chain)

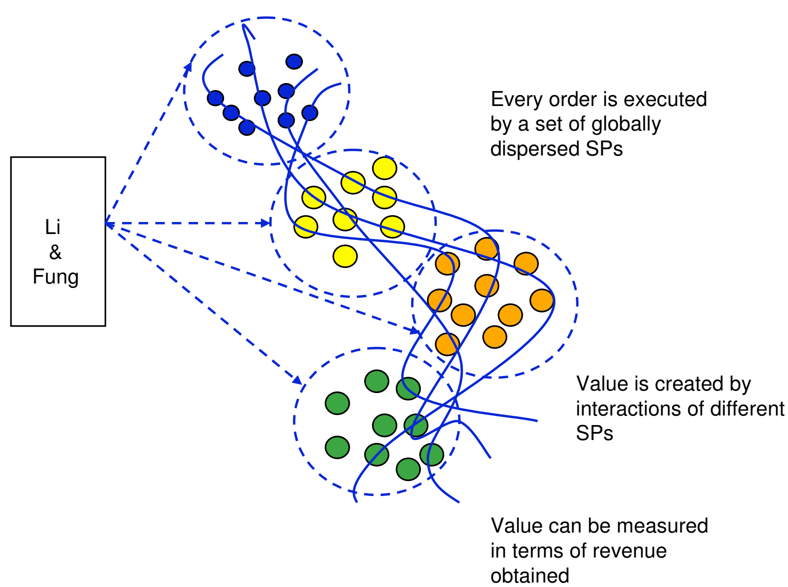
- Supply Chain ***orchestrator*** in the apparel industry
  - Does not produce any products of their own or directly participate in any stages of production within the supply chain
  - Essentially coordinates a very broad process network for apparel manufacturing
  - Coordinating 6000 factories in 100 countries
- Just the revenue for the services offered annually is USD 3 Billion (retail value of goods being much larger)
- Revolutionized the supply chain management in apparel industry

Li and Fung: Scenario



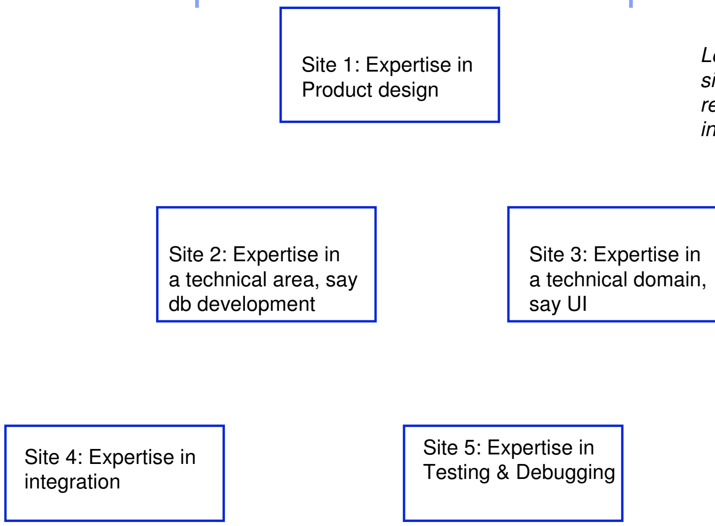
SP: Service Provider

Li & Fung



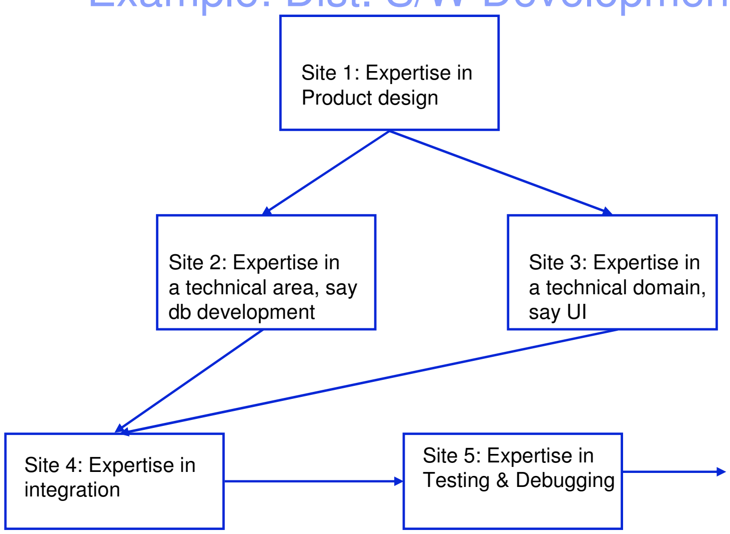
Example - Dist. S/W Development

Local Teams are formed simply by matching resource to skill set listed in project specification.



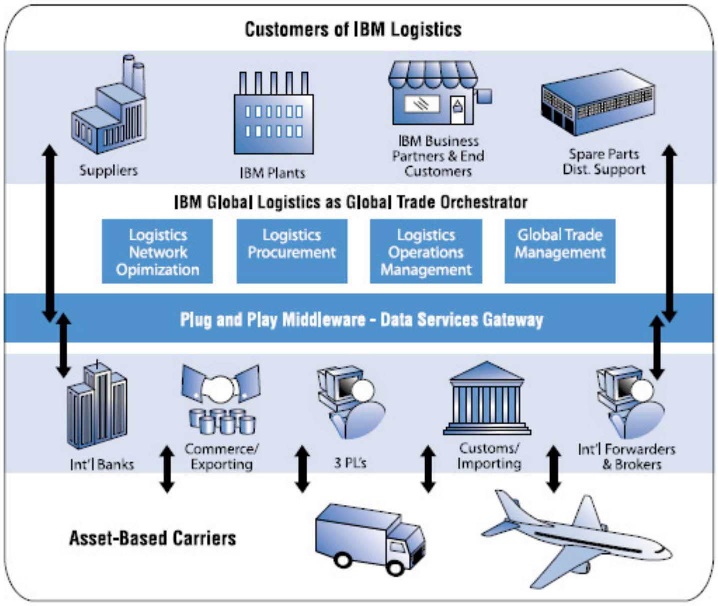
Each site has multiple teams/members who can be assigned various projects involving their expertise

Example: Dist. S/W Development



- *Projects are executed using teams from this distributed setting.*
- *Interactions of different teams create value.*
- *Value can be measured as SUCCESS or FAILURE*

Example: Global Logistics Orchestrator (GLO)



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GLO: Auctions to Choose Carriers

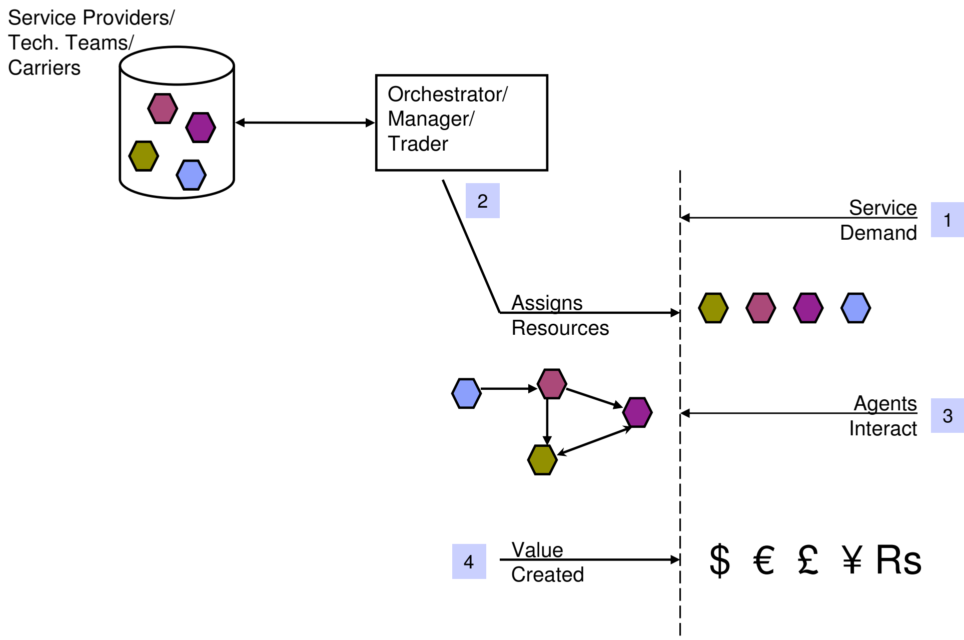
Characteristics of transportation auctions, 1996–2001

	Minimum	Median	Average	Maximum
Number of lanes	136	800	1,800	~5,000
Number of annual shipments	~6,000	88,000	~200,000	~1,500,000
Annual value of transportation services	$3M	$75M	$175M	$700M
Number of incumbent carriers	5	100	162	700
Number of carriers participating in the auction	15	75	120	470
Number of carriers assigned business from the auction	5	40	64	300

GLO: Bid Evaluation Criteria

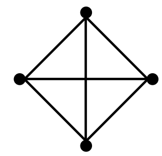
- Quantity and cost
- Business constraints
  - Incumbent Suppliers
  - Restricting Number of Suppliers
- Quality of Service
  - Picking, packaging, delivery, shipping, billing, documentation
  - Some of the above are *interaction* parameters, but are generally modeled as isolated, carrier specific parameters

Abstract Scenario

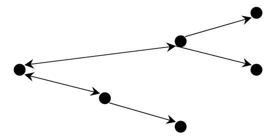


Interactions as Graphs - Examples

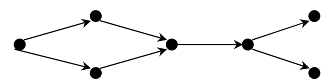
- Collaborations
  - Undirected, complete graph



- Hierarchical
  - Directed/undirected Tree



- Supply chain
  - Directed graph



In general

Connected directed/undirected graph

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Value created - Examples

- Categorical
  - Success, Failure
  - High, Medium, Low
- Continuous
  - Revenue generated
  - Ratings
- Discrete
  - Number of publications
  - Number of awards
  - Ranges (discretization of continuous)

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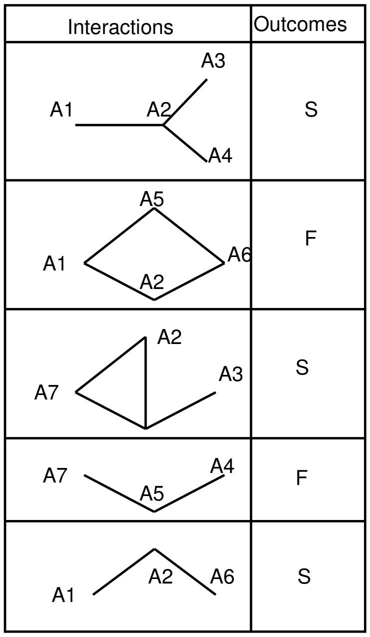
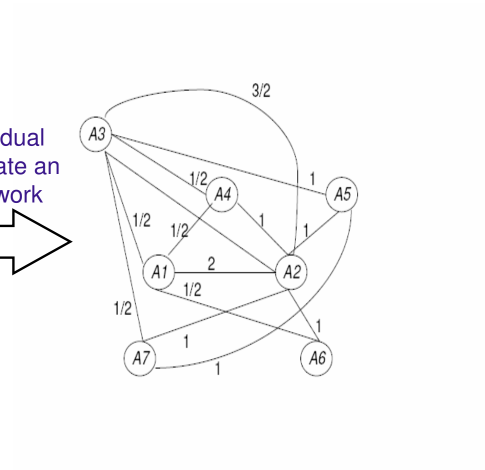
Interaction Network



Collapse the individual interactions to create an aggregate – a network



Why a Network?

- Interactions enable transfer of status, expertise, knowledge, etc – which can be captured through edges
- Any two agents may not have directly interacted, but transmission is still possible through other agents – a path in a network
- A network naturally emerges when people interact with people

Disadvantage

Temporal features are lost

Challenge

How to include values created?

Modeling Interaction Network

- How to model a network that aggregates and retains the structure of individual interactions and the outcomes of the interactions?
- Possible approaches:
  - Hypergraphs
  - Affiliation Networks
  - Graphs

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Hypergraphs

- Every interaction is an hyperedge
- Best suited for collaborations (all interact with all)
  - For other kind of interactions, the structure is lost
- Useful for studying group dynamics and team behavior
  - Q-Analysis, Simplicial complexes
- Limited by the limited theoretical understanding of hypergraphs
- How to capture values created as outcomes?

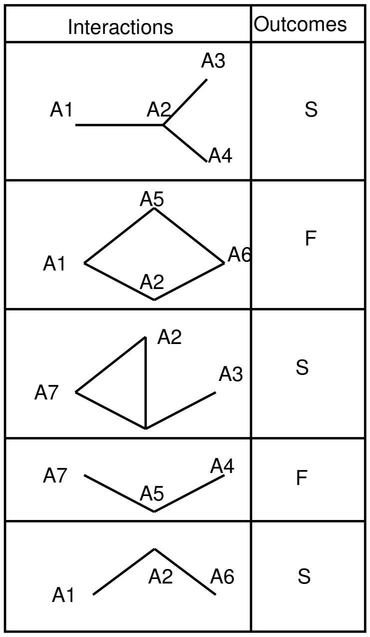
Affiliation Networks

- Bipartite graphs
  - Agents on one side and interactions on another
- Hypergraph – modeled as graph - interactions added as affiliation nodes
- Best suited for collaboration kind of interactions, as interaction pattern among the agents cannot be captured
- How to model outcomes?

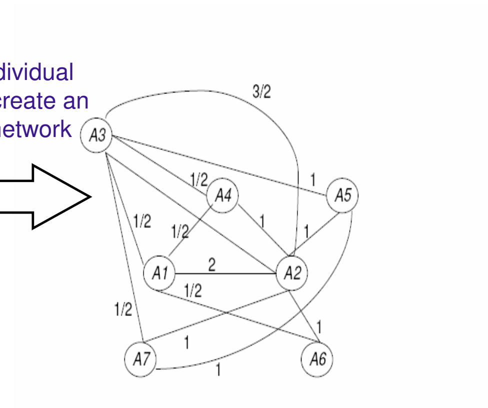
Interaction Network as Graph

- Straight forward as individual interactions themselves are graphs and hence the aggregate can be easily obtained
- SNA techniques are directly applicable
- However, only dyadic relations (between any two agents) can be analyzed.
- Analysis of higher order (subsets for group) dynamics is non-trivial
- How to model outcomes? – augment as nodes.

Augmenting Interaction Network

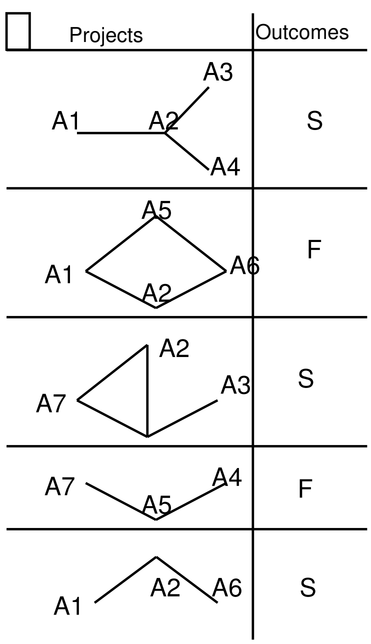


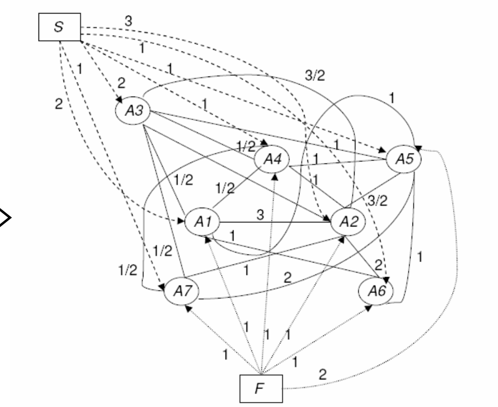
Collapse the individual interactions to create an aggregate – a network



- How about encoding the outcomes on the edges?
- Objection: Two agents could be involved in multiple interactions with different outcomes. Does it make sense to “combine”?
- Objection: The status of the outcomes is lost in “combining”

An augmentation that works well



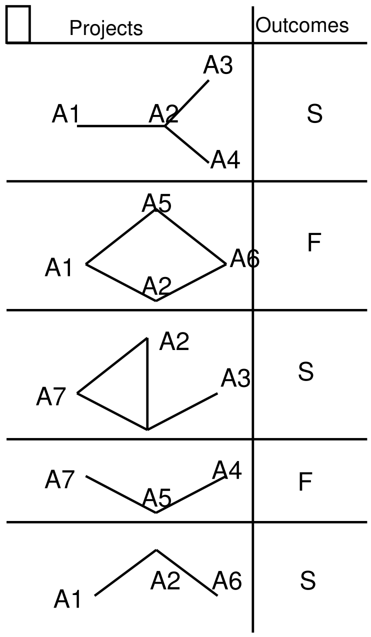


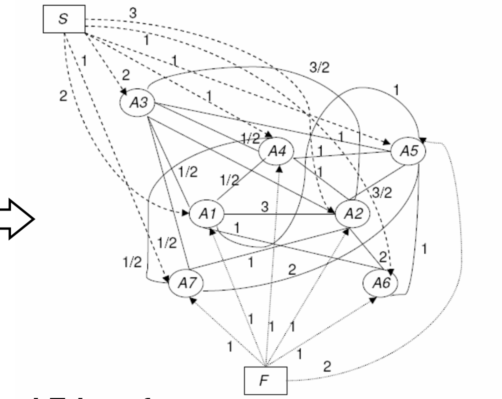
1. Special Nodes corresponding to outcomes

intuition: to retain the status of outcomes

2. Construction ensures independent status of outcomes

An augmentation that works well





Directed Edges from outcomes to agents

The outcomes influence the relative ranking/prestige of agents.

No Directed Edges from agents to outcome

The agents do not influence the ranking/importance of outcomes. For example, a outcome “success” means same thing irrespective of the agent involved.

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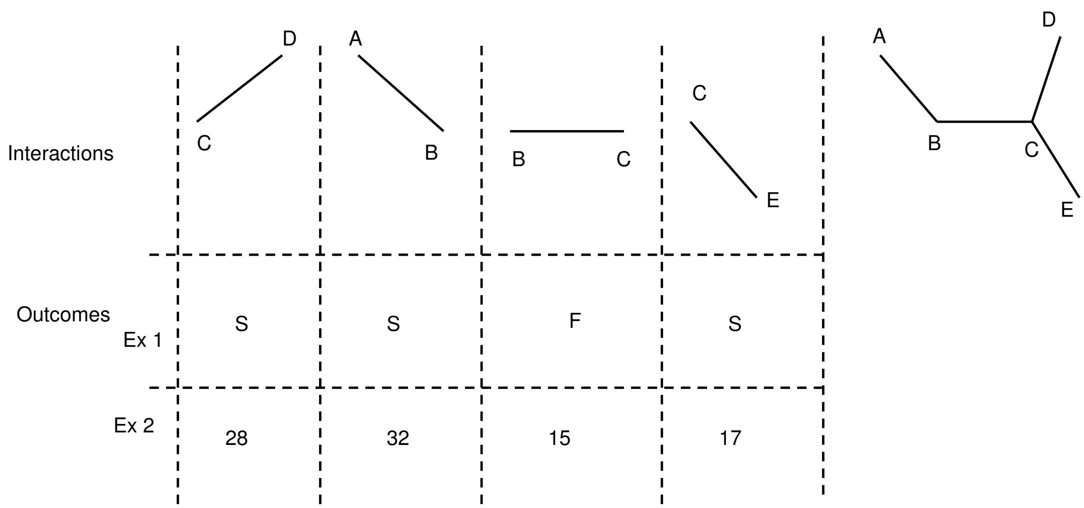
Problem Formulation



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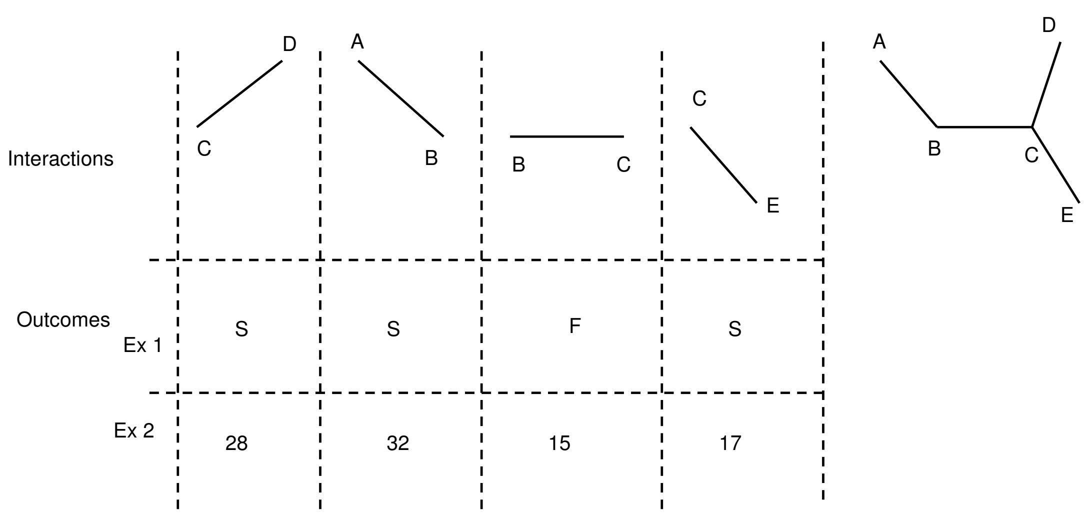
Degree Based Ranking



C, B, {A, D, E}

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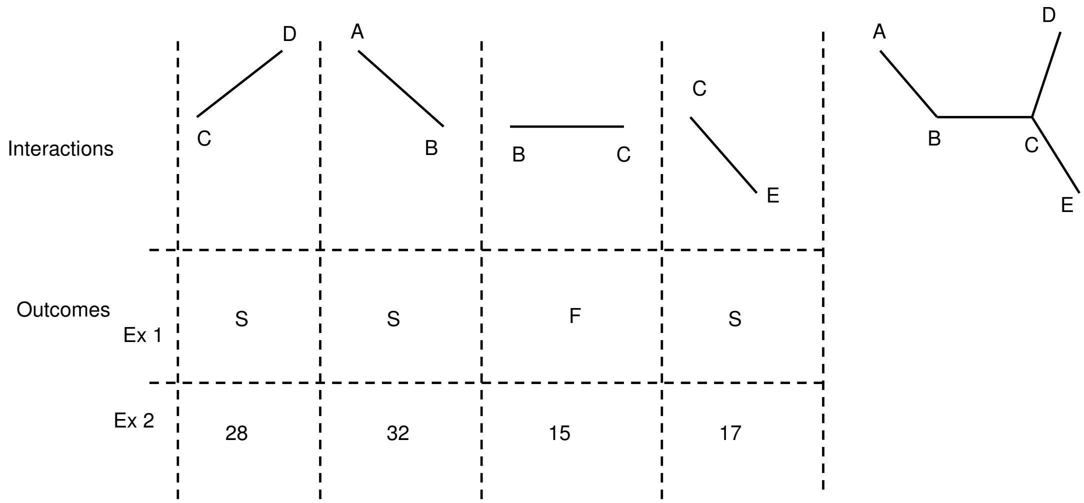
Outcome Based Ranking



C (30), B (23.5), A (16), D (14), E (8.5)
Connection of D to C is ignored!

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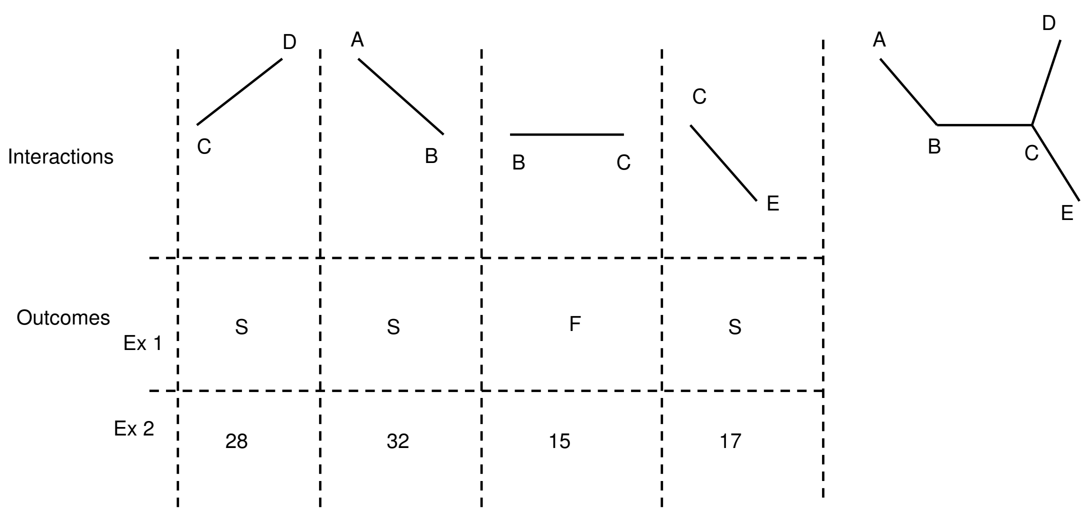
Eigenvector based ranking



C, B, {D, E}, A
A is more effective than E; but, ranked below E.

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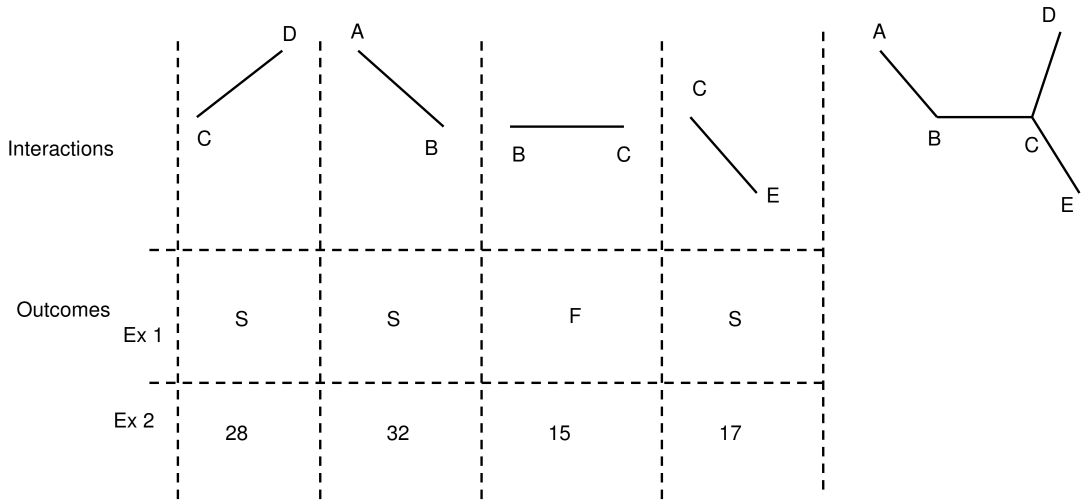
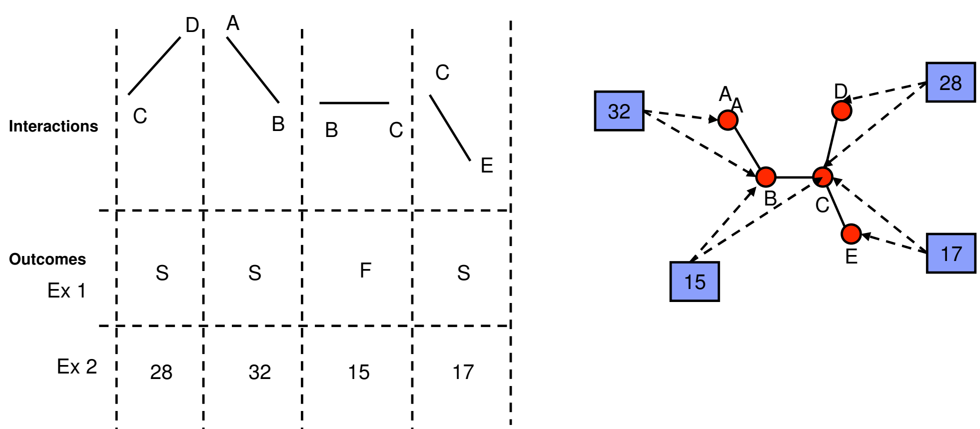
How to rank the agents?



That takes into account "structure" and "outcomes"?
Example: C, B, D, A, E

Service Interaction Network



Approach

- Work with the augmented service interaction network
- Exploit the *alpha-centrality* based approach [Bonacich]
- Use appropriate exogenous vector that captures the status of the outcomes
- The free parameter *α* is independently discovered

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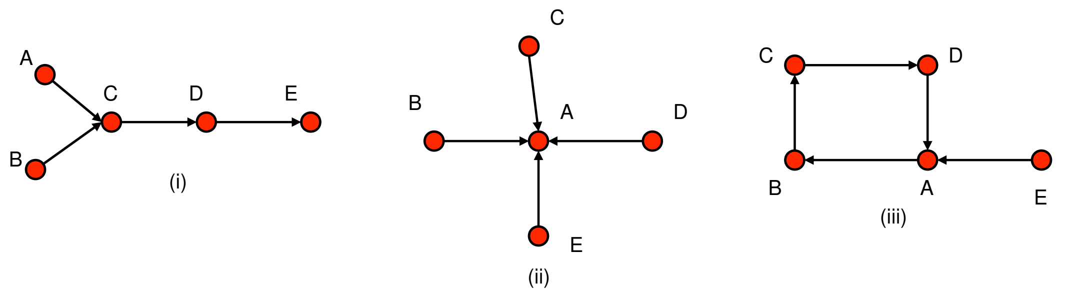
Alpha-Centrality: Motivation

Consider eigenvector-based ranking for following graphs



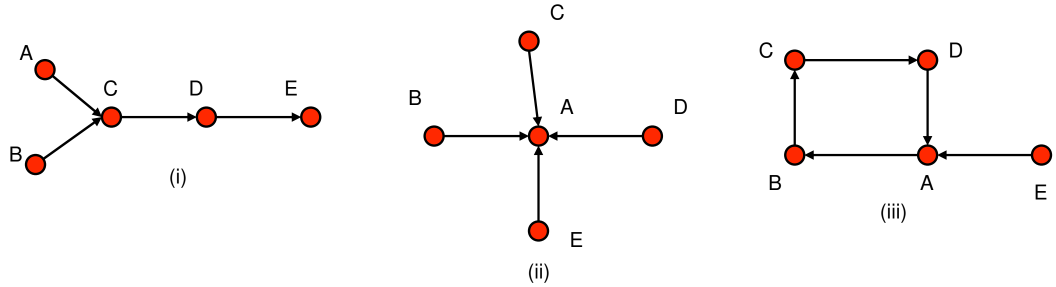
As A and B do not have any status, rest of the network also does not have status

As none of B,C,D,E have any status, A also does not have any status

As E does not have any status, its connection to A has no effect. So, A,B,C,D have equal status.

Alpha-Centrality: Idea [Bonacich 72]

Associate exogenous status for the nodes and place α-weightage on the eigenvector-like relation



Solve $x = \alpha\, A^T x + e$

Did not consider ways to set the free parameters and their effect on the results.

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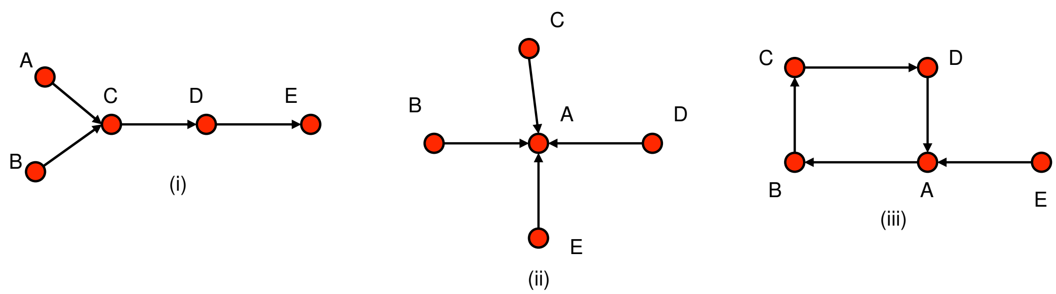
Alpha-Centrality: Some issues

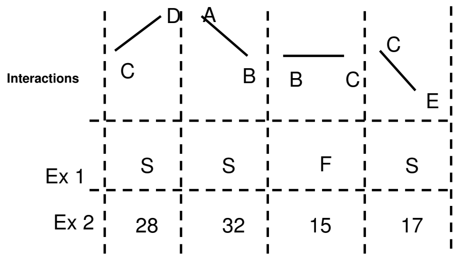
Associate exogenous status for the nodes and place α-weightage on the eigenvector-like relation

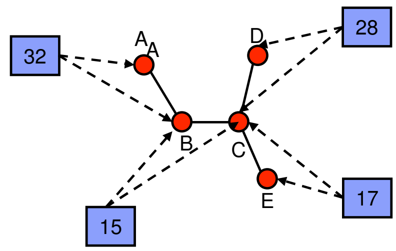


How does it work for the service interaction networks?

How to set the free parameters and understand their effects?

Alpha-Centrality on Service Interaction Networks





N – Number of players
M – Number of different outcomes

Note that
The network has (*N+M*) nodes. The N "agent nodes" are symmetric ➔ *e[i] = 1*

The M "outcome nodes" are special and have only outgoing edges.
For each outcome m, let *V(m)* denote its value. What should be *e[N+m]*? *e[N+m] = θV(m)*

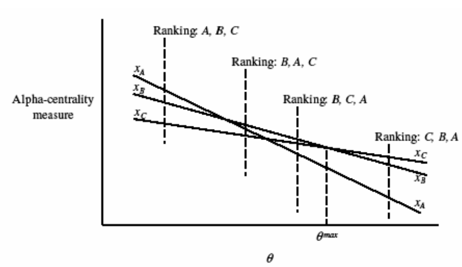
Choosing θ

Let Y be a (N+M)x(N+M): $Y=(I-\alpha A^{T})^{-1}$

By definition of A, we have

$$y_{N+m,N+m}=1,\ \forall m$$

$$y_{N+m,N+m'}=0,\ \forall m, m\neq m'$$



Rephrasing x in terms of Y,

$$x_i=\sum_j y_{ij}+\sum_m y_{i,N+m}e_{N+m},\quad \forall i$$

$$x_{N+m}=e_{N+m}\quad \forall m$$

Substituting for e,

$$x_i=\sum_j y_{ij}+\theta\left(\sum_m y_{i,N+m}V(m)\right),\quad \forall i$$

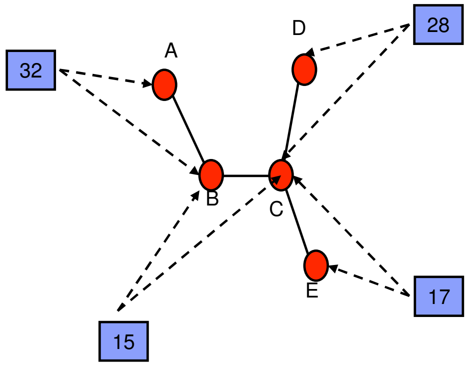
Choose $\theta \geq \theta_{max}$ such that rankings remain stable (rightmost intersection point)

Can be done in O(N²) time

Choosing α

- It is easy to derive that $\alpha \in \left(0, \frac{1}{\lambda}\right)$ is the right range for α.
- It reflects the relative importance of "structure" and "outcomes".
- When α is close to 0, outcomes seem to dominate the ranking and, when α is close to $\frac{1}{\lambda}$, structure seems to dominates the ranking. In the middle ranges, both are taken into account.
- Proof of this aspect would be very nice!

An illustration



α	Ranking
0.054,0.102, 0.15, 0.098	C,B,A,D,E (Outcomes)
0.247. 0.295, 0.343	C,B,D,A,E (Both)
0.391,0.439,0.487	C,B,D,E,A (Structure)

Here λ= (1/1.8477) = 0.54

Empirical Study of alpha-centrality

- Experiment conducted on dataset from IMD (http://www.imdb.com/interfaces).
- Lists of movies, actors in the movies, ratings for the movies, were extracted.
- Each movie is an interaction among the actors in the movie.
- Its user rating is the outcome of the interaction.
- Example: A rating of 8 indicates success; A rating of 7 and below is a failure.
- In this case, outcomes is graded instead of categorical.

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Empirical Study

- Experiment conducted on following datasets
  - A list of 28 connected actors across all times.
  - A list of 30 connected actors from old times (prior to 1980)
  - Larger networks containing 200 and 400 actors.
- Lists in both the small networks contained familiar names so that manual verification is possible.
- For larger networks, the Kendall *tau* (τ) distance was used to check the sensitivity of the method to structural and outcome changes.

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Empirical Study: Goals

- To study sensitivity to structure and outcomes.
- How different constructions of the exogenous vector impacts rankings.
- Relative importance of different actors over different periods of time should be reflected.

List 1	List 2
Brando, Marlon; Pacino, Al	Brando, Marlon; Mason, James (I)
De Niro, Robert; Bean, Sean	Calhern, Louis; Ford, Glenn (I)
Reno, Jean (I); Cheadle, Don	Malden, Karl; Johnson, Ben (I)
Travolta, John; Jackman, Hugh	Carey, Timothy; Harris, Richard (I)
Clooney, George; Pitt, Brad	Clift, Montgomery; Martin, Dean (I)
Affleck, Casey; Damon, Matt	Overton, Frank; Atterbury, Malcolm
Fredenburgh, Dan; Nighy, Bill	Ryan, Robert (I); Lancaster, Burt
Depp, Johnny; Bloom, Orlando	Sinatra, Frank; Borgnine, Ernest
Davenport, Jack; Arenberg, Lee	Marvin, Lee; Williams, Rhys (I)
Hollander, Tom; Law, Jude	Kelley, DeForest; Wayne, John (I)
Hopkins, Anthony; Penn, Sean (I)	Brennan, Walter; Wynn, Ed
Jackson, Samuel L.; Bacon, Kevin	Boyd, Stephen (I); Berle, Milton
Hanks, Tom; Buscemi, Steve	Bennett, Tony (I); Pacino, Al
Owen, Clive; Cage, Nicolas	De Niro, Robert; Crawford, Broderick
	Nelson, Ricky (I); Ebsen, Buddy

Experiment 1

- Let Ranking R1 be the ranking obtained from the original data.
- Let A1, A2 be the top ranked actors; and, let A3 and A4 be two median ranked actors.
  - A1 = George Clooney; A2=Samuel Jackson; A3 = Nicolas Cage; A4 = Orlando Bloom
- We now change the ratings of the movies in which A1 and A2 appear by two points and increase the ratings the movies of A3 and A4 by two points.
- Let Ranking R2 be the ranking obtained after the modification.
- Result: The modified rankings not only reflect changes in outcomes, but also the characteristics of the connections.
  - Tom Hanks moves to the top as he is not connected to the affected actors.
  - Don Cheadle goes down, thanks to his frequent interactions with Clooney.

Experiment 2

- Let Ranking R1 be the ranking obtained from the original data for list 1 of all-time actors.
- Let Ranking R2 be the ranking obtained for the actors in list 2 of only old actors.
- Let C be the set of common actors in the two list, say Al Pacino and Robert De Niro.
- Result: The actors in C are ranked high in the global data and at the bottom in the data upto 1980. Their “connections” status grew from their work post-1980.
  - De Niro is 9th in the global list (even though many of his frequent co-stars are missing from the experiment) and
  - And ranked last in the second list (which includes his prominent co-star Marlon Brando in the old actors list).

Experiment 3: on exogenous vector

- Every outcome is viewed as having some positive value. Example: research papers in conferences and journals.
- The outcomes could have both positive and negative value. Example: A movie with a rating of 9 is a success whereas a movie with a rating 5 is essentially of negative value.
- The outcomes could be linearly related or they could have quantum jumps
  - Revenue of $18 has a value roughly 0.9 times the value of revenue $20.
  - A paper with 1000 citations has a value more than 100 times a paper with 10 citations!
- How do these settings affect the experimental results?

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Experiment 3: on exogenous vector

- When every outcome has some positive value
  - Make the value of a movie equal to its user rating
  - In this case, the rankings do not always match intuition. Because, the "structure" dominates the "outcomes" as a great outcome like 9 is only 1.5 times better than an outcome of 6.
- When the outcomes have positive and negative value
  - Use a threshold (say rating of 6) to define success and failure. Reward success and failure proportionately in +ve and –ve range.
  - Rankings match the intuition very well.
  - The reflection of rankings after the modification in Experiment1 reflects nearly perfect results.
- When outcomes are not linearly dependent
  - In this case, the rankings matched intuition very well even though a threshold for success and failure was not used.

Experiment 3: on exogenous vector

- How to choose the exogenous vector?
  - Depends on the application (whether outcomes are categorical, graded categorical, non-linear valuations and so on)
  - Relative importance of structure and outcome
  - If any special status needs to be endowed on a subset of actors.

Experiment 4: larger networks

- Use Kendall tau measure between rankings like (R1,R2)
  - Measures how identical the two rankings are
  - It is closer to 1, if the two rankings are highly similar.
  - It is closer to -1, if the two rankings are nearly opposite to each other.
  - It is closer to 0, if they are unrelated.

- Consider the two rankings R1 (on original data) and R2 (on modifying outcomes of a subset of actors).
  - Kendall tau measure between R1 and R2 is close to zero [as expected].
  - For most simple minded modifications to the existing techniques is 0.60+.
    - Example: Enhancing eigenvector approach via SVD based ranking of the asymmetric service interaction network.
    - This highlights the importance of the exogenous vector.

Summary of Ranking

- Different from traditional ranking in social networks.
- Alpha-centrality offers a methodical way to ranking nodes when structure and outcomes have to be taken into account.
- Different parameter settings seem to characterize different ranking schemes
  - More empirical evidence of the observations or analytical explanations would be very interesting.
  - Computationally efficient most "service interaction networks".

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Overview

- Introduction
  - General
  - Leading to Service Interaction Networks
- Service Interaction Networks
  - Case Studies
  - Problems
  - Interaction Networks
- Ranking in Service Interaction Networks
- Team Dynamics in Service Interaction Networks
- Conclusion and Discussion

Given a service interaction network

- What is impact of an agent on the outcome of his interactions?
- Does the pattern of communication among the agents match with the required pattern indicated by the service being delivered?
- Given a project with non-overlapping steps how to choose "*optimal*" team?
- Can a sub-group of members form a cartel and break the whole delivery chain?
  - Alternatively, discover sub-group of players who can be move up in the value chain and become *orchestrator/manager/trader*?

Understanding Agents Contribution to Outcome

- Aggregation seems like an obvious approach
  - Effectiveness of an agent can be measure by fraction of successful projects
- Will not work in complex but frequently occurring scenarios
  - Consider presence of agents who have high affinity to either *success* and *failure.*
- An iterative update approach (additive instead of multiplicative) that works well.

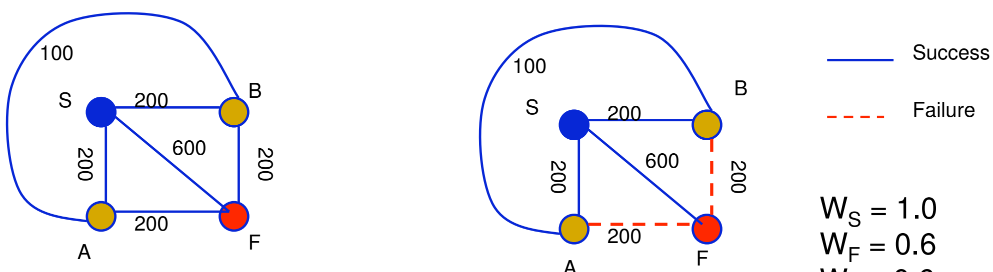
Aggregate based approach

- For an agent a

$$w_a = \frac{\sum_{W:a\in W} R(W)}{|\{W \mid a\in W\}|}$$

- Use w_as to explain outcomes
- Let *f* be the fraction of flows explained this way.

An example where it does badly



$W_S = 1.0$
$W_F = 0.6$
$W_A = 0.6$
$W_B = 0.6$

Explains only 1100 out of 1500 workflows.

An Iterative Refinement Approach

- Begin with any assignment
- Iteratively do the following till termination
  - For each workflow that is not explained
    - Increment/decrement the weights of each of its agent by a small quantity ε
    - Update depends on actual outcome: success (increment) or failure (decrement)
- The process terminates when the last *L* rounds fail to improve the fraction of explained workflows by a threshold, *M*
- Easy to see that the procedure terminates in $O(L/M^*|I|)$ time where $|I|$ is the size of the input.

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Iterative Update of Weights

- Let us associate weights with each agents, w_a for all agents
- Let $T_S >= 0.5$ and $T_F <= 0.5$ be two thresholds used for explaining outcomes
- Let W be a workflow. Let $w_{avg} = \sum w_a$ for all a in W
  - A successful W is explained if $w_{avg} < T_F$
  - A failed W is explained if $w_{avg} > T_S$

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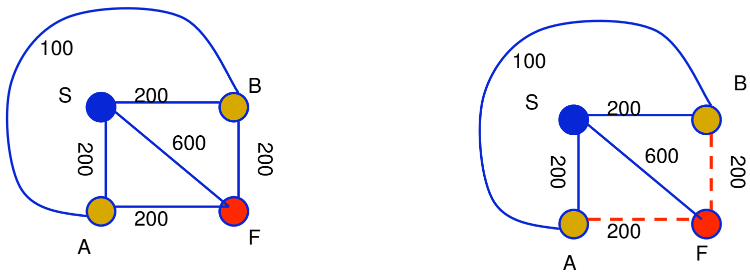
Why does it work?



$W_S = 1.0$
$W_F = 0.34$
$W_A = 0.52$
$W_B = 0.52$

These assignments can explain all the 1500 workflows.

Here, we set parameters as $\varepsilon = 0.0004; T_S = 0.5; T_F = 0.5$

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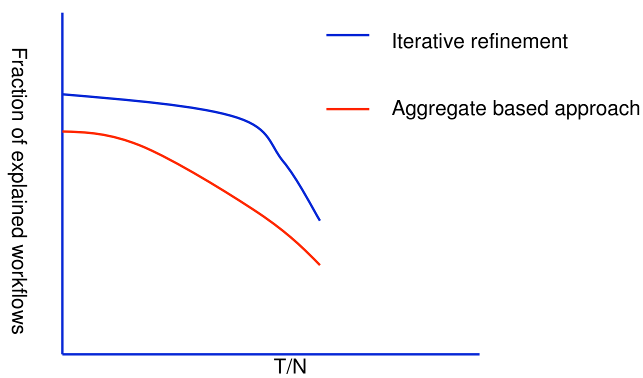
Behavior of the algorithm



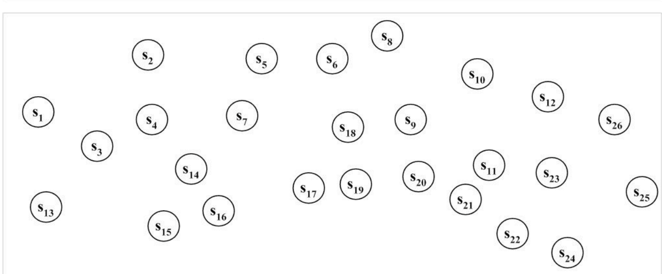
Simulation carried out with upto 500 agents and 125K workflows.
Simulation of the agents was dynamic and tried to imitate real-life aspects highlighted in the introduction.

Against different methods for assigning workflows, the improvement in fraction of explained workflows is
In the region of 0.15 to 0.20.

Understanding gaps in delivery oriented teams

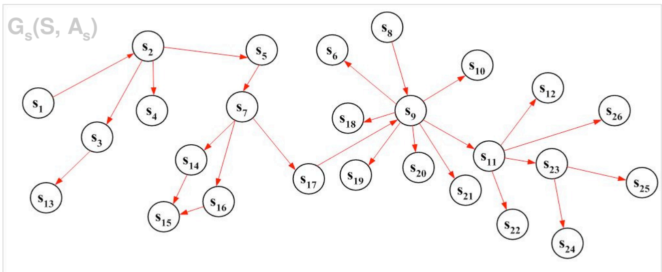
- The delivery aspect of the project can be affected by the interactions.
- Analyze the data to suggest areas in which structure and interactions could/should be improved
- Methodology demonstrated for software development
  - A set of software artifacts and interactions (calling patterns)
  - A set of people and social network
  - Interactions between software artifacts and people
- Study collaboration and co-ordination to measure congruence

Example: A set of software artifacts (S)



e.g. static analysis deps.

Example: Relationships between artifacts



e.g. static analysis deps.

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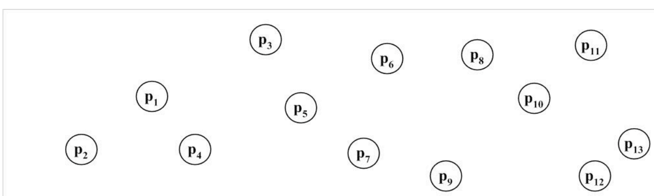
Example: A set of software artifacts (P)



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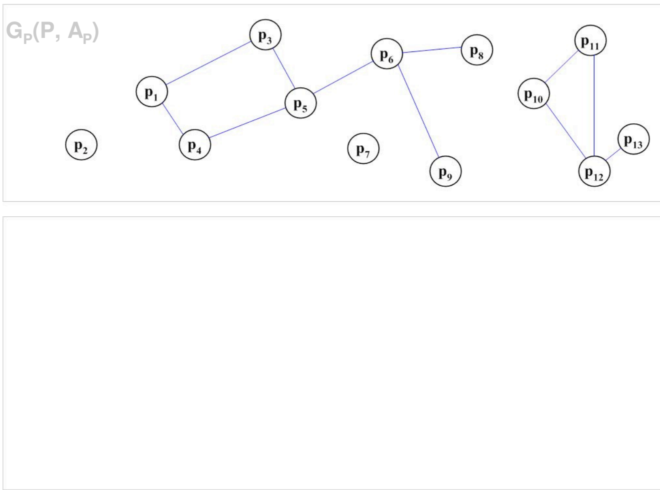
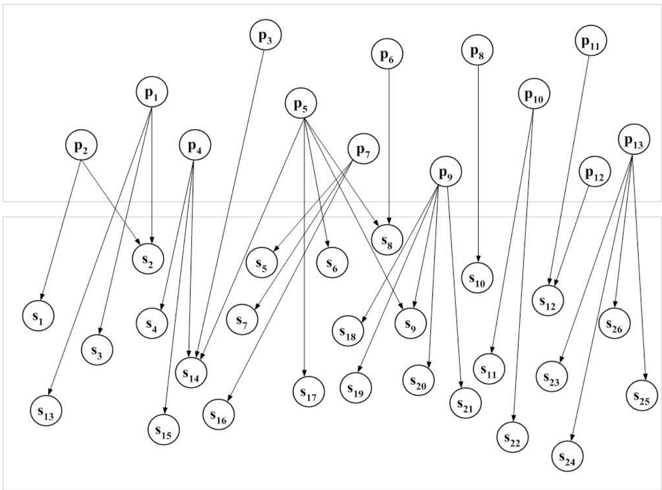
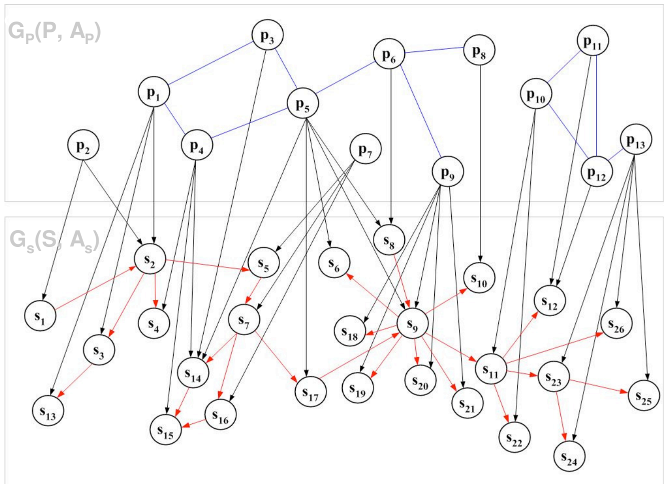
Example: The social network plane



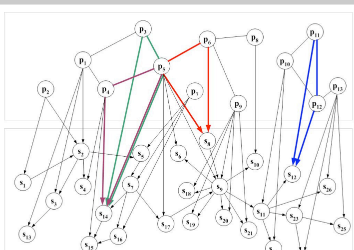
Example: People to artifacts, or *Joins* (J)



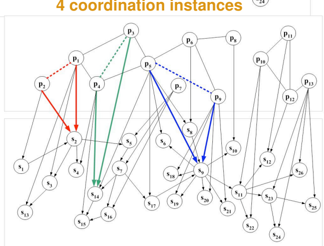
Example: The Socio-Technical Network Model



Congruence: Measuring Coordination

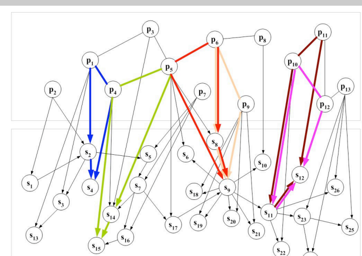


4 coordination instances

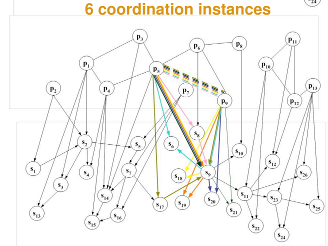


3 un-coordination instances

Node Tie Congruence = 4 / (4+3) = 57%



6 coordination instances



24 un-coordination instances (not all shown)

Arc Mirror Congruence = 6 / (6+24) = 20%

Equivalent to a measure derived from comparing matrices C and R = A • A^T

Equivalent to a measure derived from comparing matrices C and R = A • D • A^T

Collaboration (Node Tie) Congruence

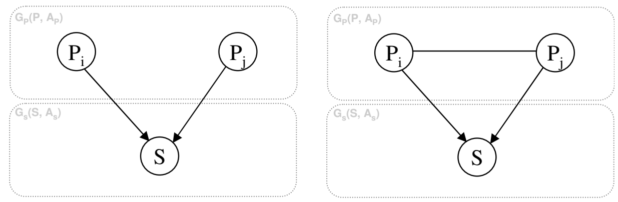
step 1: **set $\kappa, \gamma = 0$**

step 2: **For each node s in S, let J_s be the subset of J containing all arcs incident on node s. For every distinct pair of arcs (p_i,s) and (p_j,s) in J_s:**

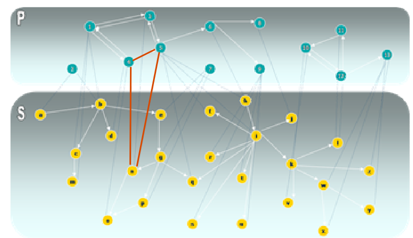
step 2a: $\gamma = \gamma + 1$

step 2b: If (p_i,p_j) is in set A_p,
then $\kappa = \kappa + 1$
else gap identified w.r.t. (p_i,p_j) and common node s

step 3: **Congruence is**
κ / γ
when $\gamma > 0$



Collaboration gap ***Collaboration***



Coordination (Arc Mirroring) Congruence

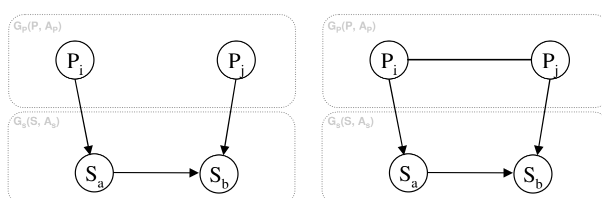
step 1: **set $\kappa, \gamma = 0$**

step 2: **For each arc (s,t) in A_S, let J_s be the subset of J corresponding to arcs incident on node s and let J_t be the subset of J corresponding to arcs incident on node t. For every distinct pair of arcs (p_i,s) from J_s and (p_j,t) from J_t:**

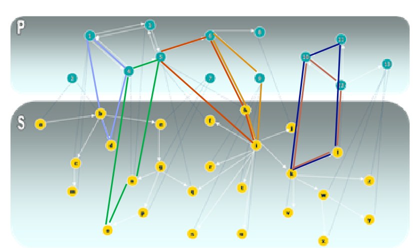
step 2a: If p_i and p_j are distinct, then $\gamma = \gamma + 1$

step 2b: If (p_i,p_j) is in set A_p,
then $\kappa = \kappa + 1$
else gap identified w.r.t. (p_i,p_j) and dependency (s,t)

step 3: **Congruence is**
κ / γ
when $\gamma > 0$



Coordination gap ***Coordination***



Understanding gaps in delivery oriented teams

- Such an analysis and associated actions can result in
  - Tightly coupled teams
  - Better flow of information among people associated with related software artifacts.
  - Will make overall development, bug fixing, change management easier to handle
- Also helps to answers questions such as:
  - Is the project at risk due to highly important communication gaps?
  - Are there failure points in the system?
  - Can we move some resources up the value chain based on the gaps they close?

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Conclusions

- Not an exhaustive survey of all the research directions in the broad, inter-disciplinary area called Service Science
- Highlighted a domain of Services that is closely related to the data analysis community
  - One that can borrow tools from it
  - And, give back new problems, paradigms, and techniques.
- Another topic that can provide similar avenues for our community is “robust forecasting in uncertain service scenarios” and its linkages to resource management such as inventory policy.

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Thank you!
&
Discussion

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Questions

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