A Smart Mall Scenario Using Promise Theory

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Motivation

- Give an example of *Promise Theory* as analysis tool.
- Analyse the behavioural patterns of autonomous agents in a *Pervasive Computing Scenario*.

Outline

The Smart Mall

The scenario includes the following actors:

- 1 Internet Service Provider (ISP).
- 1 mall.
- 3 Shops.
- 10 Customers.

Wireless Networks

- Throughout the mall (the *global* network).
- Local networks within range of each shop.
- Ad-hoc networks, formed by customers.

Mall features

- Mall and shops can send out information to online customers.
- Customers can *forward* received messages to other reachable customers.
- Forwarded messages are rewarded with *Mall Credits*.

Autonomous agents

- ISP (node 1).
- Mall management (node 2).
- Shop (node 3, 4, 5).
- Customer (node 6 - 15).

Benefits and loss (*currency*)

- ISP:
  - Payment for provided service (gain).
  - Cost of providing service (loss).
- Mall/shops:
  - Turnover/profit.
  - Reputation/popularity among customers.
- Customers:
  - Credits.
  - Information.
  - Battery power.

Potential conflicts

Between customers:

- Overflow of messages vs. gaining more credits.

Between customer and mall

- Mall wish to reach customers $\Rightarrow$ need them to download messages.
- Customers have limited battery power $\Rightarrow$ not interested in message overflow.
- Mall provides Internet access $\Rightarrow$ Customers might be tempted to exploit it.

Promise types

Promise body	Units	Category
$q, q \geq q_n$	Mb/sec	Service
$r, r = R$	Credits per message	Service
$i, i \in \{T, F\}$	True/False	Service
$d, d \in \{T, F\}$	Messages per hour	Use-message
$f, f \geq f_n$	Messages per hour	Service
$lf, lf \leq l_n$	Messages per hour	Use-value

Example promises

- $lf \leq l_n$: Keep the rate of forwarded messages below l_n *(between customers)*.
- $q \geq q_n$: Provide a minimum QoS of q_n *(from ISP to mall, from mall/shops to customers)*.
- $r = R$: Reward customer with R credits per forwarded message *(from mall/shops to customers)*.

Promise graph 1

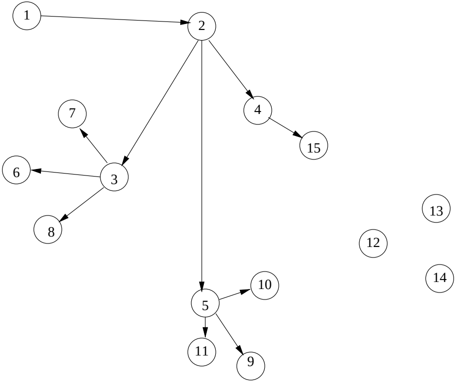

Figure: The *q*-promise graph without labels.

Promise graph 2

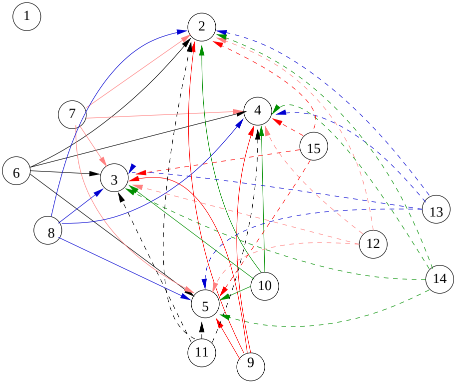

Figure: The d/f-promise graph without labels. The graphs for d and f are the same.

Promise graph 3

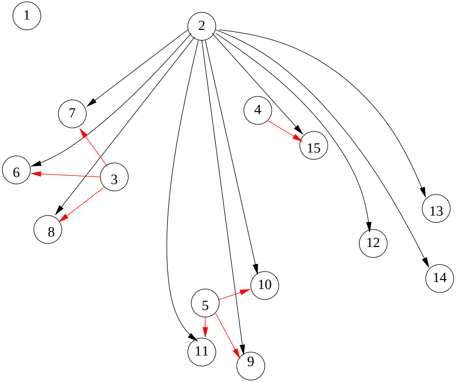

Figure: The *r*-promise graph without labels.

Promise graph 4

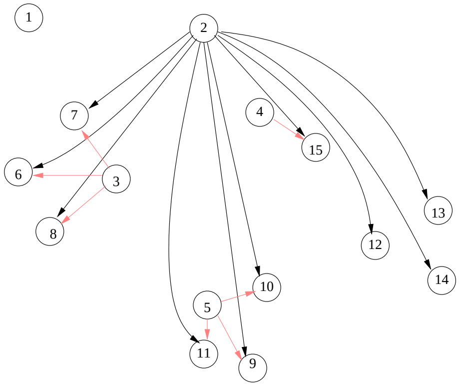

Figure: The *i*-promise graph without labels.

Promise graph 5

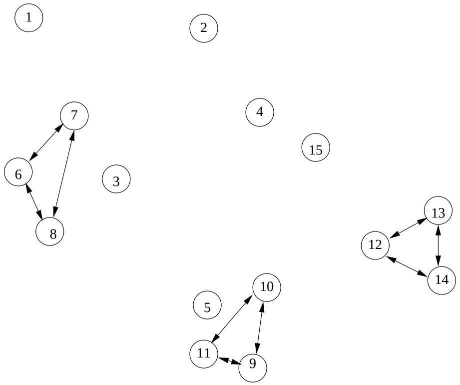

Figure: The *lf*-promise graph without labels.

Basic moves for each player

Cooperate: Keep promise.

Defect: Fail to keep promise.

Example payoff matrix

ISP, Mall	Mall cooperate	Mall defect
ISP cooperate	$P_s - C_s, S - P_s$	$0 - C_s, S$
ISP defect	$P_s, C_r - P_s$	$0, C_r$

Table: Payoff matrix for the ISP-Mall game.

Parameters: ISP-Mall game

P_s: The price or fee the mall has to pay for service.

C_s: The cost for the ISP as a consequence of providing the service.

S: The agreed level of service. This parameter is a numerical unit, associated with the *value* of the service.

C_r: The cost incurred by not having a sufficient Internet service/connection.

Games in the network

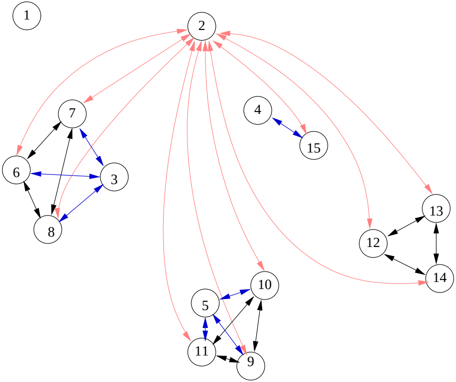

Figure: The graph of various bargaining games within the network.

Analysis: derived *roles*

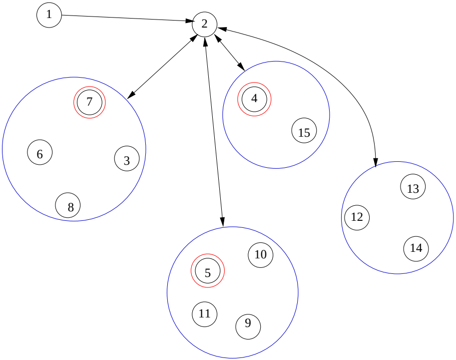

Figure: A simplified schematic graph based on the derived roles.

Example: Level of cooperation (probability)

0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
0.0	0.0	0.0	0.0	0.0	2.5	2.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	2.4	2.4	0.0	0.0	0.0	0.0
0.0	1.4	1.4	1.4	1.4	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.8	1.8	1.8	1.8	0.9	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.8	1.8	1.8	1.8	0.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.4	1.4	1.4	1.4	0.0	0.0	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0.0
0.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0
0.0	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0
0.0	1.6	1.6	1.6	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.0
0.0	1.8	1.8	1.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.9	0.0
0.0	1.6	1.6	1.6	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.0	0.0
0.0	1.4	1.4	1.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure: The sum matrix of probabilities for promises of all types, estimated over time.

Analysis: importance ranking

Rank position	Agent numbers A (Senders)	A^{T} (Receivers)	$A + A^{\mathrm{T}}$
1	2	3	2
2	13	4	3
3	7	5	5
4	8	2	7
5	12	6	8
6	14	7	4
7	3	8	6
8	6	11	13
9	9	10	9
10	15	9	12
11	10	15	14
12	5	12	15
13	1	14	10
14	11	13	11
15	4	1	1

Table: Ranking of the nodes from top to bottom. The topmost nodes are most powerful (A^{T}), or most subservient (A). Rank values for nodes {7,8} and {12,14} are identical in each case, indicating a symmetry. Also, the rank positions for {3,4,5} are identical for A^{T}.

Analysis: rank contour I

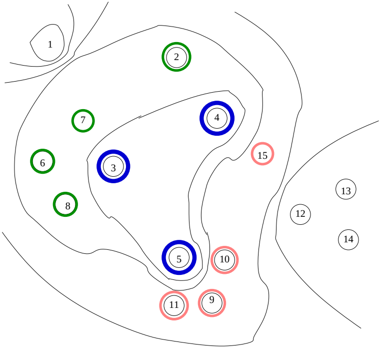

Figure: A rank contour for the model, showing the influentialness or 'power' the agents have to attract promises (strong receivers), eig(A^{T}).

Analysis: rank contour II

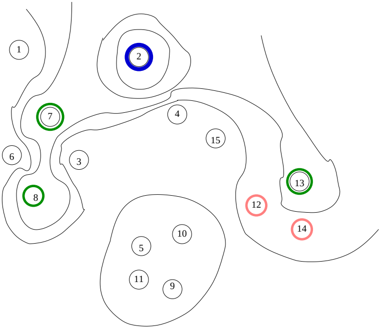

Figure: A rank contour of the 'willingness' of the nodes to offer and keep promises (strong senders), eig(A).

Analysis: removal of node

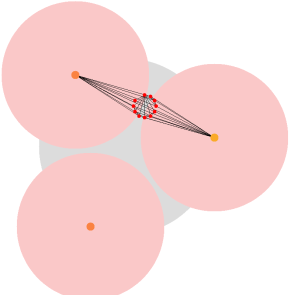

Figure: Eliminating the mall node 2 isolates the ISP node and forms two network regions dominated by two of the shops and bridged by the intermediary customers.

Summary

- We have explored a *Pervasive Computing Scenario*, using *promises*.
- We have demonstrated how the use of *Promise theory* can help predicting *coalitions* and *structures*.