An Economic Model for Resource Exchange in Mobile Peer to Peer Networks

Present:
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Outline

- Introduction
- System Model
- Resource Types
- Producer-Paid Resources
- Consumer-Paid Resources
- Experimental Analysis
- Conclusion
Introduction – (1)

- Consider an urban area with thousands of vehicles
  - Drivers and passengers are interested in information relevant to their trip

- Using database stored at fixed site, it may have some potential drawback:
  1. responses may be outdated
  2. not real-time
  3. costly
  4. not robust
Introduction – (2)

- We explore a new paradigm that is based on peer-to-peer communications
- Advantages:
  - First, better information accuracy; especially for real-time information
  - Second, cheap
    less than a cent per day, even if the communication is through all day
Introduction – (3)

- Opportunistic peer-to-peer system
  - Transmission range
  - Resource propagation
- Two type of resources
  - Producer-paid resources
  - Consumer-paid resources
- Two incentive mechanisms for two type
System Model

- **Resource Model**
  - Spatial / temporal

- **Virtual Currency**
  - Virtual Currency = coin, it is bought by real money

- **Station to Vehicle Transmission**
  - There are fixed stations and moving objects in system

- **Vehicle to Vehicle Exchange**
  - When A meet B, A will buy resources that A is interested in from B
Resource Types

- **Producer-Paid Resources**
  - Resources which the owner is interested in advertising are producer-paid
    - Example: gas station, car breakdown, emergency

- **Consumer-Paid Resources**
  - Resources which the consumer is interested in receiving are consumer-paid.
    - Example: Available parking slots

- **Producer/Consumer-Paid Resources**
Producer-Paid Resources

- **First setup Values**
  - A Producer can decide Initial budget $C$ for $R$, and commission fee $f$

- **How to incentive**
  - If $A$ has the information $R$, and $A$ encounters $B$
    - nothing happened (both have that information)
    - $A$ increase its coin counter by $f$
      - $A$ sets its budget $(C - f) / 2$, and $B$ does the same thing
  - If $(C - f) / 2 < f$, then $A$ and $B$ stop transmitting $R$
Consumer-Paid Resources (1)

- Two Mode for Consumer-Paid Resources
  - Consumer
    - Pay for Resources
  - Broker
    - Take information of resource, but can not view it
    - Earn from other Consumers
  - Switch between two mode
    - When & Why
Consumer-Paid Resources (2)

- **Price of a Resource**
  - \( F(R) = -\alpha \cdot t - \beta \cdot d \) \((\alpha, \beta \geq 0)\)
  - \( t \): time length since the creation of \( R \)
  - \( d \): the distance from the location of \( R \)
  - \( \alpha \): constant
  - \( \beta \): constant
Consumer-Paid Resources (3)

- How should $\alpha$ and $\beta$ be determined?
  - $PT = t + \frac{d}{v}$ (v is speed of vehicle)
  - Simply set the relevance is $-PT$ to $F(R)$
  - So that, $F(R) = -t - \frac{d}{v}$
  - $F(R) = -\alpha t - \beta d$ ($\alpha, \beta \geq 0$)

  - Depend on the two equations above,
  - We can set $\alpha = 1$, $\beta = 1/v$
Consumer-Paid Resources (4)

- Base on the relevance function, the price is

\[
P(R) = \begin{cases} 
E - (\alpha \cdot t + \beta \cdot d) & \alpha \cdot t + \beta \cdot d < E \\
0 & \alpha \cdot t + \beta \cdot d \geq E 
\end{cases}
\]

- \(E\) is the value of the resource to a consumer, when the parking slot becomes available.
- \(E, \alpha, \beta\) may differ for different resources.
Two “Paid” comparison table

<table>
<thead>
<tr>
<th>producer-paid</th>
<th>sender (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>receiver (B)</td>
<td>A increases its coin counter by $f$ and sets the budget of $R$ to be $(C-f)/2$. $B$ sets the budget of $R$ to be $(C-f)/2$.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>consumer-paid</th>
<th>sender (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>receiver (B)</td>
<td>consumer</td>
</tr>
<tr>
<td></td>
<td>broker</td>
</tr>
</tbody>
</table>

Both-Paid Resource

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2004/11/11
Experimental Analysis

- Simulation Setup (producer)
  - Parameters
    - Traffic speed $v$
      - $(v: 10 \sim 50 \text{ miles/hour} , + = 10)$
    - Transmission range $r$
      - $(r: 10, 50, 100, 150, 200 \text{ meters})$
    - Traffic density $g$
      - $(g: 100, 500 \text{ objects/mile*mile})$
    - Diameter of coverage area $d$
      - $(d: 0.4 \sim 2.0 \text{ mile} , + = 0.4)$

A coverage diamond area with diameter 6 blocks
Simulation results – (1)

- Percentage of reached vs. initial budget (f=0.1)

Other Parameters

- $r = 50$ meters
- $v = 40$ miles/hour
- $d = 2$ miles

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Simulation results – (2)

- Cost per reached object

Other Parameters

- $r = 50$ meters
- $v = 40$ miles/hour
- $d = 2$ miles

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Simulation results – (3)

- Impact of size of coverage area

Other Parameters

\[ r = 50 \text{ meters} \]
\[ v = 40 \text{ miles/hour} \]
Simulation results – (4)

- Impact of transmission range

Other Parameters

\( v = 40 \) miles/hour

\( d = 2 \) miles

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Simulation results – (5)

- Impact of traffic speed

Other Parameters

- \( r = 50 \) meters
- \( d = 2 \) miles
Analysis of Consumer-Paid policy

- Blind search vs. information guided search
  - **Blind search (BS):**
    - A consumer drives around the area, and he occupies the first resource that is available
  - **Information guided search (IGS):**
    - Start with a blind search, until a resource is available, and he occupies it
    - Or get information from the system, resource R is available; if another R’ is closer, he will go to R’
  - **Result**
    - The IGS search time is half of BS search time
Conclusion

- Peer-to-Peer system
  - For vehicle to exchange resources
- Two type of resources
  - Producer-paid resources
  - Consumer-paid resources
- Incentive mechanisms
  - For two types