CONTEXT AWARE ROUTING OF ENTERPRISE USER COMMUNICATIONS

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A *context aware* framework to address the diverse user communication needs of a modern enterprise.

**Approach:**

- We focus on the problem of routing communications to the most effective agent using contextual information.
  - Contextual representation of request and agent.
  - We determine an optimal ‘request-to-agent’ routing.
  - The optimal agent is selected who minimizes the expected duration of interaction while maximizes the probability of successful call completion.
- Simulations indicate that context aware routing outperforms other conventional request-routing techniques.
Customer Mary

Mary wants to buy an ipod…

Specialized ipod expert Bob

Ask about ipod deals…

Agent Alice

Need specific advice on red and green ipods… What is the impact of long-term use on hearing?

Retail floor agent Tom

Which one is shiny: red or green ipod? Available at a local store?

Mary buys the red ipod at the local store…
Current Methodology

- Current Methodology of routing requests
  - Based on queuing theory and expertise matching.
  - All agents are considered similar.

Limitations.
- Traditional closed environment in enterprises.
- Static & uniform knowledge of location, media, expertise, availability.
Agents can be at work at several places...

- Home
- Office
- Mall
- Restaurant
- Airport
- Hotel
- Retail Floor
Agents can have several media availability...
Agents can be involved in different activities...

- Driving
- Entertaining
- Interacting
- At a meeting
- Eating
- Working
- Travelling
- Do not Disturb...
Time (Availability)...

Agents can have different availability or working hours...

Availability on Monday

Availability over a week

Variation of availability over a day:
red is busy, green available
Agents can have different degrees of expertise in different areas...
Challenges

- What does such diversity really mean?
- Collaboration of people for accomplishing tasks
  - Context-aware routing is extensible to enabling collaborations among people.
  - how to decide who, how, and when to connect users for these collaborations?
- Diversity of modern enterprises
  - Location, media, expertise.
  - Enterprises are encouraging diversity.
Routing in a modern enterprise

- We address routing (a problem in enterprise communications) in an enterprise as,
  - Finding the right agent for a customer request.
  - Communication context dependent modeling.

- Relaxing the agent concept to increase productivity (open environment).
- Attempt to use the entire workforce.
- Notion that an ‘agent’ can be a special role of a regular employee.
Talk Outline

- Introduction
- Prior Work
  - Mathematical Framework
  - Request Model
  - Agent Model
  - Agent Selection Framework
- Simulation
- Experimental Results
- Conclusions and Future work

- what is context?
- collection, dissemination, and processing of context information.
- cost of interrupting users based on multiple streams of events.

But context is a dynamic construct...
Prior Work

What is context (communication context)?
- subset of knowledge that enables making efficient decisions on routing of communications.

Context aware design of applications (Dey ‘00)

Expected cost of interruption for a user using user context (Horvitz ‘03).

Pros
- Exploiting use of the 4 w’s: who, when, what and where in application design.

Cons
- Notion of ‘communication context’.
- Work on ubiquitous computing. No work in media-rich communication frameworks.
Mathematical Framework

- **Modeling Context**
  - The request context.
  - The agent context.

- **Selecting an optimal agent (request-agent matching)**
  - Optimization metric.
  - Probability of success
  - Estimate of duration of interaction.
- **What is a ‘request’?**
  - a communication that has to be routed to an agent.

- **Request Contextual Attributes**
  - Semantic Category
  - Priority

### Request Semantic Categories
- Manufacturing
- Sales
- Operations
- Troubleshooting

### Request Priorities

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantic Category</td>
<td>$C_r$</td>
<td>$C_r$ is the semantic category of request $i$.</td>
</tr>
<tr>
<td>Priority</td>
<td>$P_i$</td>
<td>$P_i$ is the priority of the $i^{th}$ request.</td>
</tr>
</tbody>
</table>
Agent Model

- **Who is an agent?**
  - Any member of the enterprise who can be called upon to handle a variety of tasks.

**Agent Model:**
  - Attributes.

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<tbody>
<tr>
<td>Availability (Hours of Operation)</td>
<td>Boolean</td>
<td>We use availability as a predicate</td>
</tr>
<tr>
<td>Location</td>
<td>$L_j$</td>
<td>$L_j$ is the location of agent $j$.</td>
</tr>
<tr>
<td>Activity</td>
<td>$A_j$</td>
<td>$A_j$ is the activity of agent $j$.</td>
</tr>
<tr>
<td>Media Type</td>
<td>$M_k$</td>
<td>$M_k$ is the $k^{th}$ media type</td>
</tr>
<tr>
<td>Media Usage and Capacity</td>
<td>$U_{jk}^k$, $c^k_j$</td>
<td>Media Usage $U_{jk}^k$ refers to the number of media channels of type $M_k$ that an agent $j$ is using at this moment. $c^k_j$ is the maximum number of requests she can attend.</td>
</tr>
<tr>
<td>Expertise</td>
<td>$E_j^r$</td>
<td>$E_j^r$ is the expertise of agent $j$ on the request semantic category $C_r$.</td>
</tr>
</tbody>
</table>
Agent Selection Framework

- **Optimization Parameters**
  - Estimated Duration of interaction.
  - Probability of successful call completion.
  - Probability of media usability.

- The metric of selection (request-agent matching)

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<td>Probability of Media Usability</td>
<td>$u_{kj}$</td>
<td>$u_{kj}$ is the media usability of agent $j$ on media type $M_k$.</td>
</tr>
<tr>
<td>Probability of Success</td>
<td>$s_j$</td>
<td>$s_j$ is the probability of success of agent $j$.</td>
</tr>
<tr>
<td>Estimate of Duration of Interaction</td>
<td>$d_j$</td>
<td>$d_j$ is the estimate of duration of agent $j$.</td>
</tr>
</tbody>
</table>
Optimization Parameters and Metric

- **Bayesian estimation of optimization parameters**
  - **Estimated Duration of interaction.**
    \[ P(d_j \mid E_j^r, M_k, U_j^k) = \frac{P(d_j, E_j^r, M_k, U_j^k)}{P(E_j^r, M_k, U_j^k)} , \]
    \[ E(d_j) = d_j \times P(d_j) \]
  - **Probability of successful call completion.**
    \[ P(s_j \mid E_j^r, M_k, U_j^k) = \frac{P(s_j, E_j^r, M_k, U_j^k)}{P(E_j^r, M_k, U_j^k)} \]
  - **Probability of media usability.**
    \[ P(u_j^k \mid L_j, A_j, M_k) = \frac{P(u_j^k, L_j, A_j, M_k)}{P(L_j, A_j, M_k)} \]
  - **The Metric**
    \[ z_j \leftarrow \max_{M_k} \left\{ \frac{P(s_j \mid E_j^r, M_k, U_j^k)}{E(d_j \mid E_j^r, M_k, U_j^k)} \times P(u_j^k \mid L_j, A_j, M_k) \right\} \]
Talk Outline

- Introduction
- Prior Work
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- Agent Selection Framework

Simulation

- Experimental Results
- Conclusions and Future work

- simulation methodology.
- agent categorization.
- choice of contextual attributes and distributions for simulation.
Simulation Methodology

- To identify a set of agent categories (mutually exclusive)
  - members of the same category are assumed to exhibit more or less similar kind of behavior.
  - Exhaustive for the communication domain.

- To identify ‘Critical Attributes’ for each agent category.
  - A critical attribute is a contextual variable whose distribution is statistically different from the average distribution of the rest of the whole population (e.g. by computing the relative entropy on the distributions).

- Select contextual variables and construct empirical distributions for them.
- Validate the matching criteria (optimization metric).
**Agent Categorization and Critical Attributes**

- **Mobile Agents:**
  - Location, Media Type, Hours of Operation and Capacity are critical attributes.

- **Regular Agents:**
  - Media Type, Hours of Operation and Capacity are critical attributes.

- **Stay-at-Home Agents:**
  - Media Type, Hours of Operation and Capacity are critical attributes.

- **High Communication Agents:**
  - Media Type and Capacity are critical attributes.

- **Low Communication Agents:**
  - Media Type, Capacity, Hours of Operation and Location are the critical attributes.

- **Reserve Agents:**
  - Media Type and Location are critical attributes.
If Activity is a critical attribute, say for regular agents, then location distribution can look like

- Gaussian

- Bimodal
Simulation Scenarios

Deployment of context-awareness:
- Agent assignment based on the probability of success.
- Estimate of duration.

Validation against traditional routing:
- Agent assignment based on agent with lowest media usage.
- Estimate of duration is constant.

Expected behavior of Simulation 2 worst, Simulation 4 best.
- Simulation 2 assigns agents using context. Fails to learn from variability of agents.
- Simulation 4 based on our context aware model.
Validation- variation in request queue length

Why request queue length?

A good model will have less requests waiting on queue.

Ideal request routing:

A minimal waiting time for customers (request queue length) and a promising degree of success (in handling of the request) within a reasonable amount of time.

Request queue for context aware case gains length much later compared to other matching schemes.
The plots of probability of success and estimate of duration for six different sets of agents (20, 50, 75, 150, 200 and 250). Context aware routing performs better.
Main Contributions

- A context aware framework for effective routing of communications from customers to agents.
- Contextual modeling of request and agent.
- Request-agent matching criteria.
- Impact the conventional staffing criteria in enterprises.
- Reduce latency in enterprise decision-making.
Limitations and Future Work

- **Limitations**
  - More rigorous analysis of request and agent context.
  - Variability among individual agents in a category.
  - Real contact center data.

- **Future Work**
  - Contextual Correlation
  - Enterprise Staffing
  - Agent Optimization
Questions?