Agent– and Web–Based Employment Marketspaces in the U.S. Department of Defense

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INTRODUCTION

Two modes of matching people with jobs prevail at present: hierarchical planning and distributed markets. Patterned after centrally planned (e.g., former Soviet-style) economies, hierarchical planning remains prevalent for matching job candidates to jobs internally *within* an organization. With evolving information technology, the internal job-matching process could be accomplished far more equitably and efficiently using Web-based markets. Intelligent agents offer excellent potential to help both employees and employers find one another in a distributed electronic marketspace. But realizing this potential goes well beyond simply changing the rules of internal job matching or making agent technology available to job searchers. Rather, the corresponding markets and technologies must be designed together to mutually accomplish the desired results (e.g., efficient and effective matching) and conform to necessary properties (e.g., market clearing, employer policies).

BACKGROUND

As an example, the U.S. Navy currently uses a centralized, hierarchical labor market to match enlisted sailors to jobs (U.S. Navy, Bureau of Naval Personnel, 2000; U.S. Navy, Commander in Chief, United States Pacific Fleet, n.d.). Navy commands (e.g., ships, bases) identify open positions, and the Navy prioritizes job vacancies based on each command's mission, current staffing levels and several other relevant characteristics. Available sailors are categorized according to their qualifications, including skills (ratings), experience, education/training, career path, and so forth. Similar skill groups are arranged in "communities". Each community has a detailer charged with matching sailors to jobs. Sailors seeking job assignments express their personal preferences to the detailer. The detailer is responsive to job priority ratings, but there is some room for discretion to tailor job assignments to the sailors' personal preferences. This centralized detailing process reassigns approximately one-third of the enlisted force every year (i.e., 100,000 sailors). This labor-intensive process often leaves both sailors and commands dissatisfied.

Competitive labor markets can be used as the model to identify the desirable characteristics of internal labor markets. Competitive labor markets are both effective and efficient (Ehrenberg & Smith, 1997). They are effective because markets clear. The wage rate adjusts to its market clearing value, where the quantity of labor that employers hire willingly exactly equals the quantity of labor that employees supply willingly. Competitive labor markets are also efficient. On the demand side, markets allocate labor to its highest valued uses. As the market wage increases, lower valued uses drop out while higher valued uses remain filled. On the supply side, markets ensure that the employees hired are the most willing to work in the industry. As market wages decrease, individuals less willing to work voluntarily leave; those most attracted to the industry remain. Thus competitive labor markets balance labor supply and demand, and ensure that the most valuable jobs are filled with the most willing employees.

Unfortunately, the information requirements to ensure effectiveness and efficiency are extensive. To operate efficiently, the assignment process must have complete information regarding the employees' preferences over available jobs, and the employers' preferences over potential employees. To establish their preferences, employees must have complete information about all relevant job opportunities, including salary, benefits and job amenities (e.g., work environment and content, promotion potential, commute), and employers must have complete information about the employees' relevant job qualifications. If labor assignments do not factor in this information, the system wastes labor by applying it to less valuable jobs, and it reduces job satisfaction, morale and retention by assigning labor to jobs that are relatively less

desirable. Clearly, some kind of technology could help people manage the required abundance of labor-market information.

INTELLIGENT AGENT TECHNOLOGY

Work in the area of software agents has been ongoing for some time, and it addresses a broad array of applications. Building upon research in the supply chain domain (Mehra & Nissen, 1998; Nissen & Mehra, 1998; Nissen, 2000), agent technology appears to have particular promise to automate and support electronic labor markets. As computational artifacts, they can help overcome human cognitive limitations (e.g., in terms of memory and processing speed), supporting rapid search and effective filtering through huge numbers of available jobs and potential employees. Further, agents possessing artificial intelligence (AI) can employ inferential mechanisms (e.g., rules, cases, scripts) to reflect and observe diverse individuals' preferences. In a domain with over a 100,000 available jobs and prospective employees (e.g., the Navy)—in which both employers and potential employees have specific, idiosyncratic needs and preferences—no other extant information technology offers the same level of automation and support capability as software agents. Here we discuss representative, extant agent technologies, and outline key capabilities of the Personnel Mall, a proof-of-concept multi-agent system developed to enact, automate and support an electronic employment market.

Extant Agent Applications

Following the literature survey and classification system of Nissen (2000), Table 1 summarizes extant agent applications into four classes: 1) information filtering agents, 2) information retrieval agents, 3) advisory agents, and 4) performative agents. Other groupings from the agents' literature could be used as well (e.g., Bradshaw, 1997; Franklin & Graesser, 1996; Nwana, 1996; White, 1997), but the classification scheme used here is useful to compare agent capabilities applicable to markets and matching processes.

Information filtering agents apply user-input preferences passively to screen and sort e-mail, network news groups, frequently asked questions and arbitrary text. Information retrieval agents collect information pertaining to commodities, such as compact disks and computer equipment, and services, such as advertising and insurance. This class also includes Web indexing robots and Web-based agents for report writing, publishing, assisted browsing, and so forth. Advisory agents provide intelligent advice and decision-support (e.g., CD and

movie recommendations, electronic concierges, agent "hosts" for college campus visits, etc.). These agents also match buyers with sellers directly in market and matching domains. Agents in this third class decide what information is needed, and seek out and use this information to make recommendations. Finally, performative agents change the state of the external world through autonomous, deliberate action (e.g., binding commercial transactions). Performative agents include marketspaces in which agents conduct business transactions, auction environments in which agents buy and sell for their users, and several agent system designs for negotiation. Performative agents also automate knowledge work, such as scheduling, autonomously provide a cooperative-learning environment and provide digital library services.

The Personnel Mall

As noted above, the Personnel Mall is a proof-of-concept multi-agent system developed to enact, automate and support a Web-based marketspace for employee/job matching (Gates & Nissen, 2001). Like its predecessor system, the Intelligent Mall (which was developed for matching buyers with vendors in products and services markets), the Personnel Mall employs a shopping mall metaphor for employee-job matching. In a mall, shoppers are not expected to know in advance which shops exist or what products they offer for sale. Similarly, shops are not expected to know which other shops are selling like products or with which shoppers they will interact. But these agent-enabled marketspaces provide a qualitative contrast to their physical marketplace counterparts; that is, instead of *people* searching, matching, buying and selling within physical markets, such market and matching activities are performed by *software agents* representing people (i.e., the sailors and commands). The agents—implemented through software objects and methods—exchange messages with one another to communicate and coordinate their activities.

The Personnel Mall is probably categorized best as a performative agent. It can represent a variety of different users—on both the demand and supply sides—to find quickly, retrieve and organize large amounts of market information. Its conformance to market and organizational rules, established for a particular enterprise or circumstance, enables this multi-agent system to automate and support commerce in a broad diversity of electronic markets, including regulation-laden, hierarchical systems. Such ability suggests the Personnel Mall offers good potential to enact, automate and support the kinds of electronic labor markets addressed through this research.

In the Navy's assignment context, command agents can be specialized to reflect the preferences and priorities

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