SmartHS: An AI Platform for Improving Government Service Provision

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Abstract

Over the years, government service provision in China has been plagued by inefficiencies. Previous attempts to address this challenge following a toolbox e-government system model in China were not effective. In this paper, we report on a successful experience in improving government service provision in the domain of social insurance in Shandong Province, China. Through standardization of service workflows following the Complete Contract Theory (CCT) and the infusion of an artificial intelligence (AI) engine to maximize the expected quality of service while reducing waiting time, the *Smart Human-resource Services (SmartHS)* platform transcends organizational boundaries and improves system efficiency. Deployments in 3 cities involving 2,000 participating civil servants and close to 3 million social insurance service cases over a 1 year period demonstrated that SmartHS significantly improves user experience with roughly a third of the original front desk staff. This new AI-enhanced mode of operation is useful for informing current policy discussions in many domains of government service provision.

Introduction

The Chinese government organizational structure follows a top-down tree-like hierarchy (Horling and Lesser 2004), which is designed to provide effective control from the top level to the grassroots level. A similar structure can be found within each government organization. Under such a structure (Figure 1), official communications between leaf nodes need to be routed through their parent nodes. This sacrifices efficiency for control. Government services provided to Chinese residents (e.g., claiming social insurance benefits, setting up an enterprise) are superimposed on top of this hierarchical structure. Most of the time, residents only directly deal with the leaf nodes which are the executive branches providing government services. A service may require several leaf nodes (not necessarily all from the same organization) each capable of rendering part of the service to form a workflow like the scenario shown in Figure 1.

The inefficiency in Chinese government service provision has given rise to an environment in which poor quality of
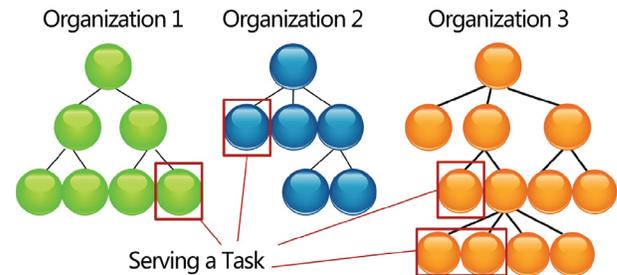
Figure 1: An example hierarchical organizational structure.

services, even moral hazard behaviours (Hölmstrom 1979), frequently occur. The prevalence of poor quality government services in China has reached a high level. This prompted the State Council of the People's Republic of China to issue official reports detailing the difficulties facing residents requiring government services (SCC 2016). The most frequently mentioned symptoms of poor quality government services include procrastination, evading responsibility, abuse of discretion, exchange of favours based on "guanxi" (i.e. personal relationship) (Park and Luo 2001), residents having to go through multiple government departments for one matter (sometimes repeatedly) and long waiting time. The poor quality of government services in China has contributed to social dissatisfaction (Easterlin et al. 2012).

Over the past decade, efforts to improve government service provision in China started to emerge (Nat 2005). Electronic government (e-government) has been identified by China as an important means for enhancing residents' access to government services. The application of e-government in countries such as the United States and Singapore has demonstrated great effectiveness in acting as a medium for delivering better services to residents and improving internal efficiency (Bertot, Jaeger, and Grimes 2010). The currently deployed e-government system in China (Seifert and Chung 2009) did not focus on breaking down the organizational boundaries across multiple government departments which are impeding task-oriented workflows, but are instead similar to electronic toolboxes for improving individual civil servant efficiency (Zhang 2002; Holliday and Yep 2005;

Li 2005; Seifert and Chung 2009). Thus, they have been largely unsuccessful in addressing systemic inefficiencies.

To address the limitations of the existing Chinese e-government model and improve the quality of government services, we propose the *Smart Human-resource Services (SmartHS)* social insurance platform. The architecture of this platform was inspired by the Complete Contract Theory (CCT) (Grossman and Hart 1983). Through the process of standardizing service provision workflows for tasks involved in social insurance, we have identified two main types of complete contract relationships among the stakeholders. The inefficiencies that exist in these relationships are the causes of many of the aforementioned symptoms of poor government service provision in China. The SmartHS platform follows a cloud-based and service-oriented technology framework (Cellary and Strykowski 2009). It is a workflow-based information and communications platform. Enhanced with an artificial intelligence (AI) engine based on multi-objective constrained optimization techniques, SmartHS replaces the current rigid organization-oriented government service provision environment with one that is task-oriented.

A workflow is modelled as a series of alternating *task execution stages* and *transition stages*:

1. During the **task execution** stage:

   (a) Providing real-time status information about the work-flow to the task requesters and the government organization involved, thereby enhancing the observability of the agents' (i.e. civil servants') actions.

   (b) Enabling performance information tracking and information sharing across organizations to support data-driven algorithmic management (Lee et al. 2015).

2. During the **transition** stage: the AI Engine optimizes the delegation of the tasks to civil servants with the required authority and competence to perform them to jointly maximize the expected quality of service and minimize the expected waiting time (Yu et al. 2013a).

In essence, SmartHS is a human-AI collaboration system (Jennings et al. 2014). As the SmartHS platform does not modify the actual incentive mechanisms (e.g., performance evaluation, performance bonus calculation, and promotion) which are currently in-place in the Chinese government, it has encountered no resistance on adoption from the government organizations involved.

After being deployed in 3 Chinese cities for a year, SmartHS has been used by 2,000 participating civil servants to serve 2.92 million social insurance cases. It has been found that residents have benefited significantly in terms of the quality of services they receive. With only 37.5% of the original front desk staff, SmartHS is able to accept social insurance service requests 10 hours per day, 7 days per week. The average waiting time has been more than halved compared to the previous system, and the total distance travelled by residents requesting social insurance services from the 3 cities is reduced by 2.61 million km (or 20.6%). The findings are useful for informing current policy discussions on reforms on government service provision in China.

Application Description

In this section, we provide a detailed description of the system architecture of SmartHS. We analyze the limitations of the existing e-government system from the perspective of Contract Theory, and explain how SmartHS addresses these limitations by fundamentally changing the conditions under which Chinese civil servants work and interact across organizational boundaries.

Figure 2: The workflow of a typical government service.

In general, a government service provision workflow consists of n intermediate steps (Figure 2). S_j denotes the jth step (i.e. an execution stage) involved in the workflow, whereas T_j (i.e. a transition stage) denotes the transition between S_j and S_{j+1}. T_j often involves passing the output of S_j (e.g., data, documents, decisions) to S_{j+1}. Since we are dealing with government services, which have precisely defined pre-requisites, rules and regulations for each S_i, the relationship between the civil servant responsible for each S_j (i.e. the agent) and his/her superior (i.e. the principal) can be modelled as a complete contract relationship (Grossman and Hart 1983). Similarly, the relationship between the civil servant for S_j (i.e. the agent), who is responsible for passing the output of S_j to the next step, and the civil servant for S_{j+1} (i.e. the principal), who depends on the civil servant from the previous step to pass the outputs to him/her, can also be modelled as a complete contract relationship. Thus, when designing SmartHS, we treat the workflow of a government service as a chain of complete contract relationships.

The Existing e-Government Model in China

Currently, there is no unified e-government system in China. Technological tools have been provided to civil servants performing each type of tasks to help them enhance their individual efficiency. For example, for a civil servant in-charge of digitizing medical bills needed for claiming social insurance, there are e-government toolkits to help him/her do so with ease. However, these tools do not organize civil servants into workflows necessary to provide different types of services. The burden of forming such workflows is often shared by residents who require such services and clerks within government organizations. The inefficiency of such a model can be illustrated with an example scenario of a resident filing a social insurance benefits claim (Figure 3).

In this scenario, the resident has to go to the front desk of a service centre as his identity and employment relationship documents need to be verified first. This information has not been integrated into the existing Chinese e-government social insurance system, and it has to be repeatedly verified for each case. Once this step is completed, the supporting documents, together with an application form, are passed on to the data entry clerk who uses an e-government tool to digitize these documents. Nevertheless, this step is for the purpose of making archival easier, and the original documents
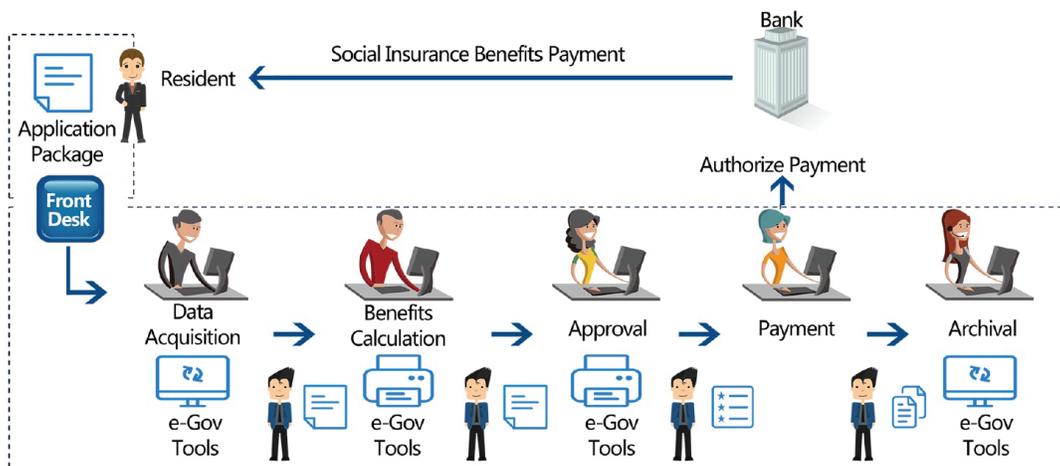
Figure 3: An example scenario of a social insurance benefits claim under the existing Chinese e-government system model.

still need to be delivered physically to the next step in the workflow – benefits calculation. In this instance, the data entry clerk is put in a position of power to determine how many cases shall accumulate at the data acquisition step before he makes a batch delivery to the benefits calculation office. He can also determine, to some extent, which incoming case to enter into the system first. Such decisions can theoretically be made based on considerations for efficiency, but in practice, are often influenced by personal preferences, the culture of "guanxi", and other forms of moral hazard. This similar situation repeatedly occurs in each step along this workflow. The civil servants in-charge of benefits calculation, approval, and payment are all put into implicit positions of power as a result of the inefficiency in the system. Thus, they are exposed to opportunities of discretion. The only one who has no opportunity of discretion is the one in charge of archiving as the transactions effectively ended before this step.

SmartHS

To address these challenges, the key is to change the working environment to minimize the inefficiencies which give rise to moral hazard. In China, such inefficiencies are often due to the existence of "guanxi" among people (Park and Luo 2001). "Guanxi" refers to networks of informal interpersonal relationships that are characterised by the exchange of favours. It is a cultural norm which has dominated Chinese people's lives for a very long time. It is unrealistic to expect that the effect of "guanxi" can be eliminated completely. Thus, in SmartHS, we use AI to automate key stages in which "guanxi" may come into play to mitigate its effect.

Figure 4 illustrates how the same scenario under Figure 3 plays out under SmartHS. This time, the resident has more channels for accessing the services. If his personal information has already been verified and saved into the system (possibly through prior interactions), he can submit his service requests electronically using networked devices via personal or workplace Internet, or the Self-service Kiosks (SKs) placed at the service centres (SCs) or other locations. Otherwise, he can still submit his service requests physically

through front desk staff in SCs in urban areas or community service centres (CSCs) in rural areas.

Once the case is entered into the system, the digitized information is used to generate tasks which are automatically delegated to suitable civil servants. Information required to perform the task at each step is automatically assembled by the system based on policy parameters, the standardized workflows and the civil servants' roles. Once a task is marked as completed, the outputs are used to generate new tasks which are delegated to suitable civil servants selected by the AI Engine from a large pool of civil servants for the next step of processing. The AI Engine uses the task-worker matching optimization approach published in (Yu et al. 2013a) which will be explained in more details in the next section (a more in-depth treatment of the approach, analysis of its proximity to the optimal solutions, and experimental comparison with alternative approaches can be found in (Yu et al. 2017a)). The status of each service case is continuously updated so that the requesting resident can track it online.

By providing a shared information infrastructure about users' identity, employment, and other important information related to social insurance claims in a secure and authenticated way, the transition stage can be fully automated by the distributed multi-objective constrained optimization approach which is implemented as a personal agent (Yu et al. 2010; Shen et al. 2016) for each civil servant. This circumvents the need for using incentives to improve efficiency in the transition stages, and eliminates the potential moral hazard facing civil servants who used to be forced to determine how frequently to deliver required documents to the next step in a given workflow. SmartHS changes the organization of civil servants from implicit positions of power to roles in order to reduce moral hazard.

Uses of AI Technology

In this section, we describe how we formulate the problem of task delegation at each transition stage in a government service provision workflow as a multi-objective constrained optimization problem and adopted the approach from (Yu et
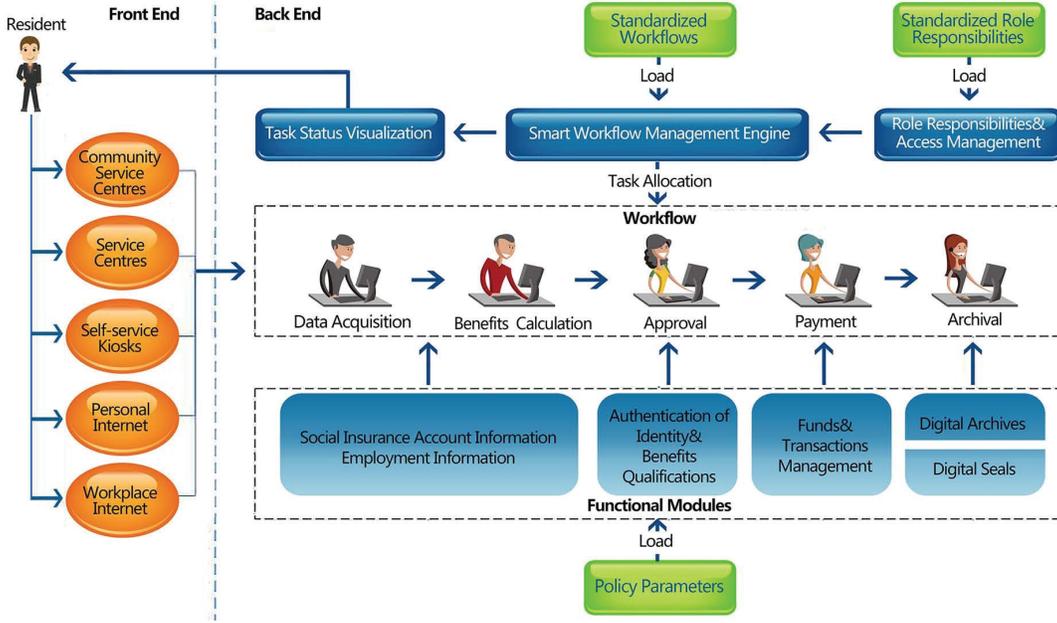
Figure 4: A example scenario of a social insurance benefits claim under the SmartHS platform.

al. 2013a) to produce solutions in real time.

System Model

In SmartHS, the system model consists of a set of N civil servants, a set of roles $\mathbf{R} = \{r_1, r_2, ..., r_K\}$, and a set of tasks $\mathbf{T} = \{\tau_1, \tau_2, ..., \tau_L\}$ at any given time t. The number of civil servants and tasks at different times may change.

- *Tasks* are associated with task profiles. Each task of type τ corresponds to a required effort level $e^{(\tau)}$ (represented in proprietarily defined Effort Units) which is determined by the system designers based on advice from civil servants familiar with the task. The normal amount of time required to complete a task of type τ, $d^{(\tau)}$, is also defined based on past experience.

- *Civil Servants* are associated with personal profiles. Each profile contains a set of roles $\mathbf{R}_i$ a civil servant i can perform. Each role corresponds to one type of task. The personal profile also tracks each civil servant's competence in performing a role. The competence is quantified by the customer satisfaction reviews provided by the residents who required the service, as well as the time taken to complete the given task in comparison to the normal amount of time required for that type of tasks. A civil servant i's competence in performing tasks of type τ based on available evidence at time t, $c_i^{(\tau)}(t)$, is computed based on the *BRSEXT* method proposed in (Yu et al. 2013b) as:

$$c_i^{(\tau)}(t) = \frac{\alpha_i^{(\tau)}(t) + 1}{\alpha_i^{(\tau)}(t) + \beta_i^{(\tau)}(t) + 2} \qquad (1)$$

where $\alpha_i^{(\tau)}(t)$ denotes the number of tasks of type τ completed within $d^{(\tau)}$ and received positive customer satisfaction reviews. $\beta_i^{(\tau)}(t)$ denotes the number of tasks of

type τ which either exceeded the normal required time or received negative customer satisfaction reviews. $c_i^{(\tau)}(t) \in (0, 1)$ with 0 indicating no competence in a given type of tasks and 1 indicating completely competent in performing a given type of tasks. The personal profile also contains a set of backlog queues $\mathbf{q_i}(\mathbf{t}) = (q_i^{(\tau)}(t))$ where τ belongs to a set of roles $\mathbf{R}_i^{(\theta)}$ for which the civil servant has a competence value $c_i^{(\tau)}(t) \geqslant \theta$. The threshold value θ is set to 0.5 in SmartHS. If a civil servant's competence in a type of task drops below this threshold, the system will issue an alert to his superior for necessary reviews. At any given moment t, the total workload backlog for a civil servant i, $Q_i(t)$ is computed as:

$$Q_i(t) = \sum_{\tau \in \mathbf{R}_i} q_i^{(\tau)}(t). \qquad (2)$$

The personal profile also keeps track of i's maximum productivity $\mu_i^{\max}$ which denotes the maximum workload he/she can complete in a given working day. The ground truth of the competence and the maximum productivity values may not be directly observable. By tracking civil servants' past performance, they can be approximated.

By defining tasks and workers around roles and competence, SmartHS takes a workflow-oriented approach to managing social insurance service provision. A workflow associated with each service can be broken down to small, well-defined tasks which can be automatically delegated to civil servants regardless of their physical locations, as long as they are authorized to perform the required role and their track records satisfy the required level of competence. The problem of maximizing the social welfare among workers in such environments is NP-hard (Yu et al. 2017a).

Maximizing Quality of Service & Minimizing Delay

From the system perspective, the workload situation for each civil servant can be modelled following queuing system dynamics as:

$$Q_i(t+1) = \max[Q_i(t) + \lambda_i(t) - \mu_i(t), 0] \quad (3)$$

where $\lambda_i(t)$ is the workload added into i's task backlog at time t and $\mu_i(t)$ is the workload completed by i at time t. In the SmartHS platform, we adopt the DRAFT approach from (Yu et al. 2013a) in the AI Engine to manage how tasks are matched to civil servants in the system.

By modelling the congestion of workload among civil servants using the Lyapunov function (Neely 2010), DRAFT formulates the problem of matching tasks to civil servants as a multi-objective constrained optimization problem:

Maximize:

$$\frac{1}{T} \sum_{t=0}^{T-1} \sum_{i,\tau \in \mathbf{R}_i^{(\theta)}} \lambda_i^{(\tau)}(t)[\rho c_i^{(\tau)}(t) - q_i^{(\tau)}(t)] \quad (4)$$

Subject to:

$$\sum_{\tau \in \mathbf{R}_i^{(\theta)}} \lambda_i^{(\tau)}(t)e^{(\tau)} \leqslant \mu_i^{\max}, \forall i, t \quad (5)$$

$$\lambda_i^{(\tau)}(t) \geqslant 0, \forall i, t \quad (6)$$

Maximizing equation (4) jointly maximizes the time-averaged expected quality of service and minimizes the time-averaged waiting time which are the two main aspects concerning customer satisfaction. Constraint (5) ensures that up to $\mu_i^{\max}$ new workload can be added into i's backlog at any time t. Constraint (6) ensures that $\lambda_i^{(\tau)}(t)$ cannot fall below 0. For simplicity of discussion, we denote the term $[\rho c_i^{(\tau)}(t) - q_i^{(\tau)}(t)]$ as the *availability index* $\Psi_i^{(\tau)}(t)$. In the SmartHS platform, the designers wish to give equal emphasis on enhancing quality of service and shortening waiting time. Thus, we set the weight variable ρ to be $\frac{\mu_i^{\max}}{|\mathbf{R}_i^{(\theta)}|}$ so that the term $\rho c_i^{(\tau)}(t)$ and the term $-q_i^{(\tau)}(t)$ from equation (4) can be of the same order of magnitude.

The algorithm SmartHS uses to recommend tasks to civil servants is shown in Algorithm 1. As it requires only local information concerning a civil servant's personal profile to compute the number of new tasks of each type to accept into his/her backlog, it has been implemented as a personal decision support agent. When there are new tasks posted, agents receive information about the new tasks and each computes how many new tasks of each type should be added to its owner's backlog in order to result in desirable collective patterns which maximizes the objective function. The SmartHS platform then coordinates the allocation of tasks to civil servants based on the distributedly computed task acceptance results. Once a task is completed, if additional steps are still required by the given workflow of the service, a new task will be created based on the results of the current completed task which will be delegated by SmartHS to other suitable civil servants following Algorithm 1 again. In this way, the decentralized architecture combined with a strong algorithm enables SmartHS to scalably translate system-level objectives into individual-level task delegation decisions to achieve high collective productivity.

Algorithm 1 SmartHS Task Recommendation

Require: The sets of new tasks at time t, $\mathbf{Q}^{(\tau)}(t)$, $\forall \tau \in \mathbf{R}_i^{(\theta)}$; $q_i^{(\tau)}(t)$ and $c_i^{(\tau)}(t)$ values $\forall \tau \in \mathbf{R}_i^{(\theta)}$; $\mu_i^{\max}$.
1: $e_i(t) = \mu_i^{\max}$
2: Sort all $q_i^{(\tau)}(t)$ in i in descending order of their $\frac{\Psi_i^{(\tau)}(t)}{e^{(\tau)}}$ values;
3: **for** each $q_i^{(\tau)}(t)$ in i **do**
4:     **if** $\frac{\Psi_i^{(\tau)}(t)}{e^{(\tau)}} > 0$ **then**
5:         **if** $|\mathbf{Q}^{(\tau)}(t)|e^{(\tau)} \leqslant e_i(t)$ **then**
6:             $\lambda_i^{(\tau)}(t) = |\mathbf{Q}^{(\tau)}(t)|$;
7:         **else**
8:             $\lambda_i^{(\tau)}(t) = \left\lfloor \frac{e_i(t)}{e^{(\tau)}} \right\rfloor$;
9:         **end if**
10:         $e_i(t) \leftarrow e_i(t) - \lambda_i^{(\tau)}(t)e^{(\tau)}$;
11:     **else**
12:         $\lambda_i^{(\tau)}(t) = 0$;
13:     **end if**
14: **end for**
15: **return** $\lambda_i^{(\tau)}(t)$ for all $\tau \in \mathbf{R}_i$;

Application Use and Payoff

SmartHS has been deployed in three Chinese cities – Dongying, Weihai and Yantai since December 2015. It has been used by 2,000 participating civil servants for providing social insurance services to residents of these three cities. In this section, we analyze the effects of the SmartHS platform on social insurance service provision. We compare the performance achieved by SmartHS with data from these three cities under the previous e-government system (e-Gov) following the toolbox model. The performance data for SmartHS were gathered from January 2016 to December 2016 for 12 months.

Figure 5(a) shows the average time taken for the top 10 most frequently requested services under g-Gov and SmartHS, respectively. The 10 services are ranked in descending order of the average time taken under e-Gov. It can be observed that under SmartHS, the average time taken to serve these frequently requested services has decreased significantly. Under e-Gov, each of these 10 services requires 35 days on average. Under SmartHS, this average time is reduced to 14 days, resulting in 59% shorter waiting time.

Figure 5(b) illustrates the cumulative percentage of services completed over different lengths of time for all available social insurance services. It can be observed that within 2 weeks' time, e-Gov was able to process 22% of all requests, whereas SmartHS was able to process 38% of all requests. Under SmartHS, 67% of all services can be completed within one month from the date of being requested, whereas under e-Gov only 31% can be completed over the same duration. All service requests under SmartHS can be completed within 100 days. It takes 210 days under e-Gov to complete all service requests.

Figure 5(c) shows the breakdown of the average time taken for the different stages involved in the workflows for
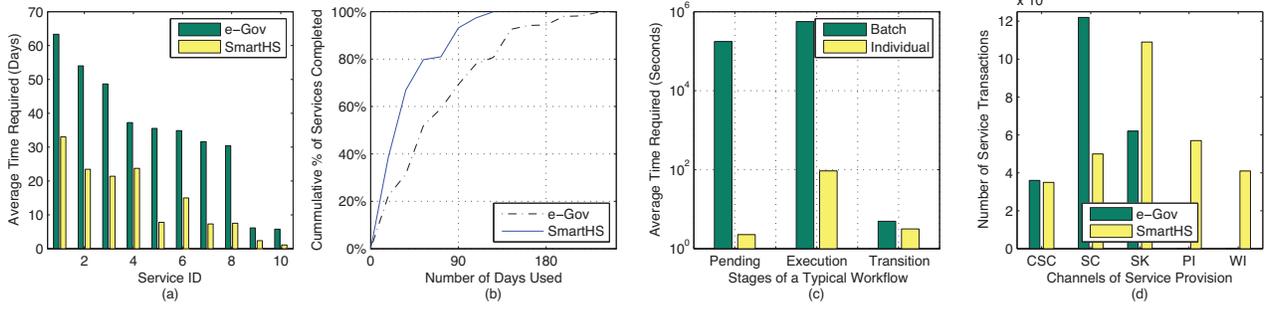
Figure 5: Results: **(a)** the average time taken for the top 10 most frequently requested social insurance services in 3 Chinese cities: Dongying, Weihai and Yantai; **(b)** the cumulative percentage of services completed within x number of days; **(c)** the average time spent (expressed in seconds) on different stages of batch tasks and individual tasks under SmartHS (**note:** the y-axis is drawn in logarithmic scale); **(d)** the usage patterns of different channels for accessing social insurance services (CSC: Community Service Centre; SC: Service Centre; SK: Self-service Kiosk; PI: Personal Internet; and WI: Workplace Internet).

service provision under SmartHS. Tasks in SmartHS can be divided into two categories based on how they are processed: 1) *batch tasks*, which require someone in a position of authority to process multiple tasks in one go (e.g., authorizing payment); and 2) *individual tasks*, which can be serviced immediately by one or more qualified civil servants to whom the system can dynamically delegate the task based on availability. Once a task is delegated to a civil servant by SmartHS, it stays pending in his/her backlog until it is processed. This stage is referred to as the pending stage in Figure 5(c). For batch tasks, the average pending time is around 2 days and the average processing time is 6.5 days. For individual tasks, the average pending time is around 2 seconds and the average processing time is 93 seconds. Once the tasks are completed, they are automatically forwarded to the next step in the workflow by the AI Engine. Thus, the average transition time depends only on the system processing time and the network transition time (between 3 to 5 seconds).

Figure 5(d) illustrates the different usage patterns under SmartHS and e-Gov. Under e-Gov, residents can access social insurance services manually through SCs which are located in municipal areas, CSCs which are located in rural areas, or SKs. As SmartHS can be accessed via any Internet enabled device, residents can also use their Personal Internet (PI) or Workplace Internet (WI) to obtain social insurance services. During the one year period prior to the deployment of SmartHS, CSCs served 0.36 million service requests. CSs served the most service requests numbering 1.22 million. Another 0.62 million requests were served by SKs. During the one year period after the deployment of SmartHS, CSCs served 0.35 million requests, which is similar to e-Gov. This can be attributed to the relatively low Internet penetration rates in rural areas in China where most residents have to access government services physically through front desks. There is a significant drop in the number of services accessed through SCs in urban areas from 1.22 million to 0.50 million after the deployment of SmartHS. SKs now attracts the most number of usage at 1.09 million. The number of services requested via PI with SmartHS is

0.57 million whereas that via WI is 0.41 million. Before SmartHS, only 28% of all the requests were filed electronically through SKs equipped with e-Gov. With SmartHS, 71% of all the requests are filed online (via SKs, PI and WI). Under SmartHS, an additional 0.72 million services have been completed compared to e-Gov, which represents a 33% increase. The change in usage patterns suggests that residents prefer SmartHS over the old system. Under e-Gov, each front desk staff needs to serve on average 7.9 social insurance service applications per hour. Under SmartHS, the number of front desk staff was reduced by 62.5% and yet, each of them only needs to serve on average 0.85 social insurance service applications per hour.

Table 1: The average travel costs by different channels of accessing social insurance services for residents.

Channel — Travel Cost	Avg. Round Trip	Avg. Time
SC	20km	3 hours
CSC	4km	0.5 hours
SK	1km	0.17 hours
PI	0km	0 hours
WI	0km	0 hours

The change in usage patterns brought about by SmartHS has also resulted in significant savings on travel cost for residents requesting social insurance services. The average round trip distance and the average travel time required for each channel of accessing social insurance services are listed in Table 1. Under e-Gov, residents from the three cities travelled 12.70 million km per year to access social insurance services. Under SmartHS, this distance is reduced to 10.09 million km even when the total number of services provided increased by 33%. Overall, SmartHS, through re-designing the system around workflows and innovative application of AI techniques, saves the residents 35.4 years (or 17.3%) of travel time and 2.61 million km (or 20.6%) of travel distance, enough to circumnavigate the globe 65.25 times.

Application Development and Deployment

The SmartHS platform was developed using the Java Programming Language by Dareway Software Co. Ltd (http://www.dareway.com.cn/) located in Jinan, Shandong, China. When developing the AI Engine, we have evaluated multiple potential algorithms which are capable of operating under our system model including (Basu Roy et al. 2015; Ho, Jabbari, and Vaughan 2013; Yu et al. 2013a). The decision for selecting (Yu et al. 2013a) is three fold:

1. (Basu Roy et al. 2015; Ho, Jabbari, and Vaughan 2013) require integer linear programming (ILP), which has high computational complexity, in order to solve the optimization problem. Thus, they cannot deal with the dynamic changes in civil servants' personal profile information and availability in real time. In comparison, (Yu et al. 2013a) can be implemented as a distributed approach which is highly scalable for handling such dynamic changes.

2. (Yu et al. 2013a) not only can offer provable performance bounds, but also enables the system administrator to control the trade-off between expected quality of service and expected waiting time with a single control variable. Thus, it offers more flexibility in terms of defining the overall collective productive behaviour by the participating civil servants.

3. As (Yu et al. 2013a) rotates the types of tasks to be added into a civil servant's task backlog at different points in time, it helps reduce the monotony of work and thereby, enhances the work experience for the civil servants.

The user interface of SmartHS for a civil servant is shown in Figure 6. As it is developed for use in China, the language used in the user interface is Chinese. The new tasks recommended by the SmartHS agent to this particular civil servant at the time the screenshot was taken are listed in the red rectangular area labelled as "(A)". The tasks in this particular civil servant's current backlog at this time are listed in the green rectangular area labelled as "(B)". This is the mechanism through which the AI Engine communicates with the civil servants involved.

Maintenance

As time goes by, there are additions of new workflows, changes in personnel and changes in operating parameters in SmartHS. Since the data concerning tasks and personnel are separated from the AI Engine and treated by the task delegation approach as inputs, they can be easily updated without affecting the AI Engine. The optimization algorithm rarely needs to be modified. Since deployment in December 2015, there has not been any AI maintenance task.

Conclusions and Future Work

In this paper, we reported our experience addressing the challenges of poor quality of government service provision in China with AI. We developed the SmartHS platform to standardize the service workflows following complete contract relationships and incorporate AI into the platform to automate task delegation in order to achieve high collective productivity. By dynamically optimizing civil servants'

workloads to jointly maximize the expected quality of service while minimizing waiting time, the AI Engine helps breakdown organizational boundaries and enables civil servants to work in an environment similar to defined task crowdsourcing (Doan, Ramakrishnan, and Halevy 2011; Yu et al. 2015a; 2015c). Without modifications to the existing incentive structures in Chinese government organizations, the system has so far been deployed in three cities in China. Over a 1 year period during which SmartHS was used by 2,000 participating civil servants to serve close to 3 million social insurance service requests, the platform has demonstrated significant advantages in terms of improving residents' user experience through reduced travel costs in filing applications and reduced waiting time. The benefits brought by SmartHS have been noted by the State Council of the People's Republic of China (http://www.gov.cn/xinwen/2016-03/13/content_5052885.htm). Further plans to deploy SmartHS in more cities and other branches of civil service in China have been put in place. The experience gained is being analysed to advise related policies in China.

In future, we will investigate how to enhance the AI Engine to provide data-driven algorithmic management to support more complex collaborations among civil servants in order to further improve system efficiency. We are studying recent advances in AI literature including task sub-delegation optimization approaches (Yu et al. 2015b; 2016) and the mood-based productive laziness optimization approach (Yu et al. 2017b). We are also looking into explainable AI approaches (Fan and Toni 2015) to automatically generate explanations on the AI recommendations to help government officials better understand the rationale behind these recommendations in order to improve user acceptance.

References

Basu Roy, S.; Lykourentzou, I.; Thirumuruganathan, S.; Amer-Yahia, S.; and Das, G. 2015. Task assignment optimization in knowledge-intensive crowdsourcing. *The VLDB Journal* 24(4):467–491.

Bertot, J. C.; Jaeger, P. T.; and Grimes, J. M. 2010. Using ICTs to create a culture of transparency: E-government and social media as openness and anti-corruption tools for societies. *Government Information Quarterly* 27(4):264–271.

Cellary, W., and Strykowski, S. 2009. E-government based on cloud computing and service-oriented architecture. In *Proceed-*

Figure 6: The user interface of SmartHS for civil servants (with personal information deleted).

ings of the 3rd International Conference on Theory and Practice of Electronic Governance (ICEGOV'09), 5–10.

Doan, A.; Ramakrishnan, R.; and Halevy, A. Y. 2011. Crowdsourcing systems on the world-wide web. *Communications of the ACM* 54(4):86–96.

Easterlin, R. A.; Morgan, R.; Switek, M.; and Wang, F. 2012. China's life satisfaction, 1990–2010. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* 109(25):9775–9780.

Fan, X., and Toni, F. 2015. On computing explanations in argumentation. In *AAAI*, 1496–1502.

Grossman, S. J., and Hart, O. D. 1983. An analysis of the principal-agent problem. *Econometrica* 51:7–46.

Ho, C.-J.; Jabbari, S.; and Vaughan, J. W. 2013. Adaptive task assignment for crowdsourced classification. In *ICML*, 534–542.

Holliday, I., and Yep, R. 2005. E-government in China. *Public Administration and Development* 25(3):239–249.

Hölmstrom, B. 1979. Moral hazard and observability. *The Bell Journal of Economics* 10(1):74–91.

Horling, B., and Lesser, V. R. 2004. A survey of multi-agent organizational paradigms. *The Knowledge Engineering Review* 19(4):281–316.

Jennings, N. R.; Moreau, L.; Nicholson, D.; Ramchurn, S.; Roberts, S.; Rodden, T.; and Rogers, A. 2014. Human-agent collectives. *Communications of the ACM* 57(12):80–88.

Lee, M. K.; Kusbit, D.; Metsky, E.; and Dabbish, L. 2015. Working with machines: The impact of algorithmic and data-driven management on human workers. In *CHI*, 1603–1612.

Li, B. 2005. On the barriers to the development of e-government in China. In *ICEC*, 549–552.

2005. New accountability in China: A Chinese funding agency has a new constitution, supporting better selection. Will it spread? *Nature* 434:1053.

Neely, M. J. 2010. *Stochastic Network Optimization with Application to Communication and Queueing Systems*. Morgan and Claypool Publishers.

Park, S. H., and Luo, Y. 2001. Guanxi and organizational dynamics: Organizational networking in Chinese firms. *Strategic Management Journal* 22(5):455–477.

2016. The guidance of the State Council on accelerating the work of Internet government services. Technical report, The State Council of the People's Republic of China.

Seifert, J. W., and Chung, J. 2009. Using e-government to reinforce government–citizen relationships: Comparing government reform in the United States and China. *Social Science Computer Review* 27(1):3–23.

Shen, Z.; Yu, H.; Miao, C.; Li, S.; and Chen, Y. 2016. Multi-agent system development MADE easy. In *AAAI*, 4391–4392.

Yu, H.; Cai, Y.; Shen, Z.; Tao, X.; and Miao, C. 2010. Agents as intelligent user interfaces for the Net Generation. In *IUI*, 429–430.

Yu, H.; Miao, C.; An, B.; Leung, C.; and Lesser, V. R. 2013a. A reputation management model for resource constrained trustee agents. In *IJCAI*, 418–424.

Yu, H.; Shen, Z.; Leung, C.; Miao, C.; and Lesser, V. R. 2013b. A survey of multi-agent trust management systems. *IEEE Access* 1(1):35–50.

Yu, H.; Lin, H.; Lim, S. F.; Lin, J.; Shen, Z.; and Miao, C. 2015a. Empirical analysis of reputation-aware task delegation by humans from a multi-agent game. In *AAMAS*, 1687–1688.

Yu, H.; Miao, C.; Shen, Z.; Leung, C.; Chen, Y.; and Yang, Q. 2015b. Efficient task sub-delegation for crowdsourcing. In *AAAI*, 1305–1311.

Yu, H.; Miao, C.; Shen, Z.; and Leung, C. 2015c. Quality and budget aware task allocation for spatial crowdsourcing. In *AAMAS*, 1689–1690.

Yu, H.; Miao, C.; Leung, C.; Chen, Y.; Fauvel, S.; Lesser, V. R.; and Yang, Q. 2016. Mitigating herding in hierarchical crowdsourcing networks. *Scientific Reports* 6(4).

Yu, H.; Miao, C.; Chen, Y.; Fauvel, S.; Li, X.; and Lesser, V. R. 2017a. Algorithmic management for improving collective productivity in crowdsourcing. *Scientific Reports* 7(12541).

Yu, H.; Shen, Z.; Fauvel, S.; and Cui, L. 2017b. Efficient scheduling in crowdsourcing based on workers' mood. In *ICA*, 121–126.

Zhang, J. 2002. Will the government 'serve the people'?: The development of Chinese e-government. *New Media & Society* 4(2):163–184.