Resource Integrated Urban Design Method in Regulatory Detailed Planning

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Abstract. In order to promote the rationality of urban resource integration process, an urban resource integration method based on repeated game control scheme is proposed in the Article. Firstly, construct the optimal model of urban integration decision-making, quantify the operation level of dominant factor, consider the hardware and software strength for urban resource integration; secondly, a repeated game control scheme is proposed in the Article, in which the algorithm is based on Nash bargaining solution and the finite repeated game process, which could fully optimize the optimal model of urban integration decision-making; lastly, verify the effectiveness of proposed methods by simulation examples.

Keywords: Resource integration, urban competition, repeated game, Nash equilibrium, Resource optimization.

1. Introduction

Currently, with deepening of social division, the global economy has been driven by services, in which productive services have continuously promoted the growth of cities, while the strengthening of city services is an essential factor to keep lasting competitiveness for cities. The strengthening of city services is not a one-dimensional transition to service-oriented city, but a fine and balanced action with various business logics coexisting, in which urban sector and service sector will fuse, dependent with each other, as well as positive interaction and the boundary between the both has been blurred. Only by technology advance could not make urban sector keep competitive advantage and the product-service combination strategy applied by urban and service sector within cities might be a new way to gain such competitive advantage, the resource allocation against service differentiation competition at strategic level has been adjusted, which means an integration solution based on differentiation by combining service which is related to products, so as to promote the competitiveness of its core products and effectively promote the same of cities. We can see that, there has been a new "symbiotic relation" between cities and service, and the urban competition within the whole world has turned to the competition between service and the whole industrial system progressively, from the original competition between product function and quality.

Currently, the studies targeted in service-oriented cities are mainly focus on its concept, origin, value creation mechanism and application practice, however, what service-oriented cities provide are those service oriented in the whole lifetime of products, including the realization, maintenance, monitoring and upgrading transformation, mechanism of supplies, hosting, training and other overall value-added services of the "product service system", unfortunately, there has no relatively mature integration theory and quantitative standards formed to guide the practice. From the view of system value theory, the key to achieve resource integration is to systematically integrate the resources corresponding to each of production/service activities within the network, and to achieve optimization and value adding of the whole resource network after the single city value adding is met, so as to clarify integration suitability for individuals and to reasonably judge and select quality resources from the network. The key point is to integrate the logistics, capital flow, information flow operation level of those individual resources such as brokers, suppliers, 3PL and outsourcers, thus to provide customers with high value product service system and achieve value adding for overall and related cities. Therefore, the logistics, information flow, capital flow and product structure and other hard environment factors of resource individuals within SMN will be the criterion to balance the adaptability of resource individual integration.

The integration of network resources by service-oriented cities is a process to promote the overall operation level of system. The integration strategies are able to improve the hard environment factors of each participated urban individuals, such as logistics, information flow, capital flow and product structure, making the three-flow cohesion smooth. Meanwhile, reforming the soft environment factor operation level which coordinates with the service concept of urban individuals could optimize product structure. From the view of system and value chain appreciation, resource integration requires improvements both in hard environment and soft environment. Therefore, the hard (soft) environment factors which dominate the network and individual operation level will be considered as dominant factors for resource integration in the Article. According to the complex relationship among those factors, we can see: firstly, each dominant factor interacts with each other and the input cost will not only improve itself but also the operation level of other factors. Secondly, there will be a complex input and output relationship upon integration, the output formed by entering integration cost will be the promotion of overall operation level. Thus, the integration cost shall be divided in proportion to improve the hard (soft) environment of system and such cost will be allocated to each dominant factor in specific proportion while inside the same environment.

2. Optimization Model of Integration Decision-making

2.1 Precondition and Related Description on Establishment of Model

(1) Before the construction of integration decision optimization model, the operation level of dominant factors must be quantified, with steps as follows: ① before service-oriented cities providing network integration decision scheme, widely survey each resource individual and dig out the main sub-factor that dominates each dominant factor during individual operation. ②According to the scale unit corresponding to operation characteristics setting of each sub-factor, conduct standardization, which means $f_i = (x_i - x_{min}) / (x_{max} - x_{min})$, in which, f_i is the operation level of the *i* sub-factor within a certain dominant factor, for a determined dominant factor, the value range of *i* is determined by the quantity of its main sub-factors; x_i is the actual value indicated in the scale of operation level of the sub-factor corresponding to the surveyed individual; x_{min} and x_{max} are the maximum and minimum value in the scale table of operation level of the sub-factors corresponding to all resource individuals to be integrated. ③Determine the average value according to the significance of each individual to each sub-factor and determine the weighting ω_i of each sub-factor when deciding the operation level of such dominant factor. ④ Determine the operation level of dominant factors of each individual according to the weighting above and the measured value of f_i, means $F = f_i w_i$.

(2) During survey, the operation level of dominant factor of individuals shall be quantified reasonably and the complex relation among those dominant factors shall be dug by correlation analysis to determine the contribution level of integration cost of each dominant factor invested by each individual on improving itself and other factors under same environment and improving each dominant factor in different environment. In which dominant factors related to hard environment include logistics, capital flow, information flow and product structure, and those related to soft environment include service concept, action mode, organization structure and business procedure, and the single code means the strength of influence on improvement of operation level of the latter by the investment cost of the former on the clockwise direction by corresponding dominant factor in row and column. During integration operation, reasonable impact strength value shall be subject to survey and analysis to refine and classify the indicators of the source of operation level of each dominant factor of each individual, then quantify according to accurate cost estimate and statistical inductive method.

2.2 Integration Decision Model

Theory of Constraints (TOC) is a kind of management theory based on constraints and proposed by Dr. Eliyahu M.Goldratt, an Israeli physicist. Such theory believes that, in a network of link by link and with tight junction, each city is dependent on each other and each individual action will affect the overall performance of system. The most contributable part of such theory is that, it guides cities on how to collectively use the limited resources and how to apply such limited resources into the most essential part in the whole system, so as to achieve maximum benefit. Now the application of TOC has extended to supply chain from internal production management within cities, Yao Jianming and Liu Liwen made optimization of the resource integration decisions within the supply chain under 4PL by application of TOC, they constructed the model, but until now, there is no scholar carried out study on the TOC application in resource integration within service oriented cities. This Article, attempts on modeling on this field by application of TOC, with purpose to achieve TOC expansion from supply chain to resource network.

Consider that the overall target of resource network integration optimization decisions in service-oriented cities is determined by the minimum integration cost, including software, hardware cost and the total tolerance with minimum time limit. Such concept could be abstract as the optimal target function in formula (1), and the realization requires conformance with some constraints.

$$\min Z = \min(C_{soft.i_k} + C_{hard.i_k}) + \beta_{\min}\theta_k \tag{1}$$

In the formula above, the optimization target is the minimum of time limited tolerance when the system integrating cost and production/service activities.

3. Repetitive Game Control Scheme

3.1 Nash Bargaining Solution

Since NE has low efficiency, cooperation among players might be introduced to obtain an effective solution of Pareto. Two factors will be needed in such process: (1) the public region formed by feasible utility set of all players shall be compact and convex. (2) The dangerous point might be defined as NE solution of one game. The public region might be expressed as [16]:

$$R = \left\{(u_1, u_2, \cdots, u_N) \middle| (p_1, p_2, \cdots, p_N) \in [0, P_i^{\max}]^N \right\} \tag{2}$$

As a strategy set, $\mathcal{S}_1, \cdots \mathcal{S}_N$ is compact, because $\mathcal{S}_i \in [0, p_i^{\max}]$ and the utility function u_i is continuous, for a given city allocation, the region is compact. Since it is always non-convex, time division scheme might be an effective solution. In order to clarify the specific process of the solution, a system with two users is considered. At time τ, the urban resource integration effect value is (p_1, p_2), and the utility function of users will be (u_1, u_2). At time $(1-\tau)$, the urban resource integration effect value is (p_1', p_2'), and the utility function of users will be (u_1', u_2'). Thus, we could get a new public region (system with two users) as follows:

$$\begin{aligned} \bar{\mathcal{R}} = \{(\tau u_1 + (1-\tau)u_1', \tau u_2 + (1-\tau)u_2') \\ \left| 0 \le \tau \le 1, (u_1, u_2) \in \mathcal{R}, (u_1', u_2') \in \mathcal{R}\right) \end{aligned} \tag{3}$$

In which, the Pareto convex boundary of $\bar{\mathcal{R}}$ is defined and Figure 1 gives the convex public region which has both NE point, NB solution and Nash curve.

Define R^{NB} as NE with improved public region, the expression will be:

$$\mathcal{R}^{NB} = \left\{u_i \ge u_i^{NE} \middle| i \in [1, 2, \cdots, N]\right\} \tag{4}$$

NB solution belongs to the region $\mathcal{R}^{NB}$, and in the urban resource integration effect value control game $\mathcal{G}$, NB solution is the only one exists and could be defined as $u^{NB}=\left(u_1^{NB},u_2^{NB},\cdots,u_N^{NB}\right)$, with specific expression as follows:

$$u^{NB}=\max_{\substack{u_i\in\mathcal{R}^{NB}\\ i\in[1,2,\cdots,N]}}\prod_{i=1}^{N}(u_i-u_i^{NE}) \tag{5}$$

Since NE is always available, and the utility region is compact and convex, there is NB solution exists. The NB solution by intersection of Pareto boundary $\bar{\mathcal{R}}^{*}$ and the Nash curve has an expression of $m=\prod_{i=1}^{N}(u_i-u_i^{NE})$, in which m is a constant option, which makes itself an intersection point as shown in Figure 1. Although NB solution is Pareto effective, it requires the channel state information (CSI) of transmitter. By study on dynamic repeated games (RG), there is another effective solution available.

3.2 Definite Repeated Game (DFG)

RG is a long term and interactive game, in which players will make decision on future based on experience reflection on the past, to achieve optimization of the decision result. The moment that all players choose a game stage for their actions is expressed as *t*. thus an action frame might be defined for all players, which is $\boldsymbol{p}(t)=\left(p_1(t),p_2(t),\cdots,p_N(t)\right)$. And the historical information $\boldsymbol{h}(t)$ at time *t* by player *i* will be expressed as a vector pair:

$$\begin{aligned}(P_{y,t},p_{i,t})=(&P_y(1),P_y(2),\cdots,P_y(t-1),\\ &p_i(1),p_i(2),\cdots,p_i(t-1))\end{aligned} \tag{6}$$

It depends on the set $\mathcal{P}_i=\left[0,P_i^{\max}\right]=\left[0,P^{\max}\right],\mathcal{H}_t=\left(\Delta^{t-1},\mathcal{P}_i^{t-1}\right)$ since all users have the identical maximum urban resource integration effect value. The historical experience in RG might be used by players as basis to coordinate their action at each stage and the reason is that all players know well about those historical experiences. Use $\delta_{i,t}$ to indicate the strategy of player i, the action of such player might be expressed as:

$$\delta_{i,t}=\left|\begin{array}{l}\mathcal{H}_t\rightarrow\left[0,P_i^{\max}\right]\\ h(t)\mapsto p_i(t)\end{array}\right. \tag{7}$$

Definition 2: the corporate strategy $\boldsymbol{\delta}$ meets with balance conditions of RG, which is defined as $\left(\mathcal{N},(\mathcal{S}_i)_{i\in\mathcal{N}},(v_i)_{i\in\mathcal{N}}\right)$, if $\forall i\in\mathcal{N}\ v_i(\boldsymbol{\delta})\geq v_i(\delta_i',\boldsymbol{\delta}_{-i})$, in which $v_i=v_i^T$, to meet:

$$v_i^{\lambda}(\boldsymbol{\delta})=\sum_{t=1}^{+\infty}\lambda(1-\lambda)^{t-1}u_i\left(\boldsymbol{p}(t)\right) \tag{8}$$

One of the characteristics of DRG is that it has minimum quantity of stages (T_{min}). If the stage number in game was proved to be $T>T_{min}$, a more effective balance point might be achieved. Or if there is $T<T_{min}$, the NB process will be implemented. We assume that the city gain $|g_i|^2$ is within the compact set $\left[v_i^{\min},v_i^{\max}\right]$, following proposition will be proposed:

Proposition 1: (DRG balanced), we assume following conditions are met:

$$\lambda\leq\frac{\Psi}{\Gamma+\Psi} \tag{9}$$

In which:

$$\begin{cases} \Theta = \dfrac{Av_i^{\max}}{bv_i^{\min} + \overline{\gamma}_i \sigma^2 B} - \dfrac{Gv_i^{\max}}{bv_i^{\min} + \tilde{\alpha} H} \\ \Lambda = \dfrac{Ev_i^{\min}}{bv_i^{\max} + \gamma_i^* \left(\sigma^2 + \sum_{j \neq i} p_j^* v_i^{\max} \right) F} \\ \Omega = \dfrac{Cv_i^{mm}}{bv_i^{\max} + \hat{\gamma}_i (\sigma^2 + \sum_{j \neq i} p_j^{\max} v_i^{\max}) D} \end{cases} \tag{10}$$

Following actions might be used to define the T stage of DRG corresponding to NE:

$$\delta_{i,t} = \begin{vmatrix} \tilde{p}_i, t \in \{1, 2, \cdots, T - T_{\min}\} \\ p_i^*, t \in \{T - T_{\min} + 1, \cdots, T\} \\ p_i^{\max}, otherwise \end{vmatrix} \tag{11}$$

In above formula, $A = Rq(1-\phi(\overline{\gamma}_i))$, $B = \dfrac{q(1-\phi(\overline{\gamma}_i))}{f(\overline{\gamma}_i)}$, $C = Rq(1-\phi(\hat{\gamma}_i))$, $D = \dfrac{q(1-\phi(\hat{\gamma}_i))}{f(\hat{\gamma}_i)}$, $E = Rq(1-\phi(\gamma_i^*))$, $F = \dfrac{q(1-\phi(\gamma_i^*))}{f(\gamma_i^*)}$, $G = Rq(1-\phi(\tilde{\gamma}_i))$, $H = \dfrac{q(1-\phi(\tilde{\gamma}_i))}{f(\tilde{\gamma}_i)}$. γ_i^* Is the SINR at NE, and $\overline{\gamma}_i$ is the SINR of maximum utility and minimum utility, with corresponding algorithms as follows:

Algorithm 1: DRG balanced
Input: through*put* and urban resources, maximum urban resources integration effect value $P^{\max}$, size of buffer zone *K*, data package arrival rate *q*, and the urban resources integration effect value consumption *b* and the discount factor λ. Output: Expected utility points able to maximize all city states. Step 1: Each city resource is in the first stage of the game $t \in \{1, 2, \cdots, T - T_{\min}\}$, make data output at the new OP point by using urban resources integration effect value $\tilde{p}_i$; then, make energy efficiency indicators calculation according to the Section 2.2 Step 2: Each city resource is in the second stage of the game $t \in \{T - T_{\min} + 1, T - T_{\min} + 2, \cdots, T\}$, if the condition (18) is met, implement the NB balance: $\delta_{i,t} = \begin{vmatrix} \tilde{p}_i, t \in \{1, 2, \cdots, T - T_{\min}\} \\ p_i^*, t \in \{T - T_{\min} + 1, \cdots, T\} \\ p_i^{\max}, otherwise \end{vmatrix}$ Step 3: According to formula (9-10), calculate the utility function, $u_i(\boldsymbol{p}) = \chi_i(\boldsymbol{p})$, $\chi_i(\boldsymbol{p}) = \dfrac{Rq(1-\Phi(\gamma_i(\boldsymbol{p})))}{b + \dfrac{qp_i(1-\Phi(\gamma_i(\boldsymbol{p})))}{f(\gamma_i(\boldsymbol{p}))}}$; Step 4: Detect whether the constant urban resource indicators kept in stage 1 have changed, if yes, measure the deviation; Step 5: Punish the utility function at point of deviation. Step 6: if the stage number in game was proved to be $T > T_{min}$, a more effective balance point might be achieved. Stop the algorithm and input the optimal multi-address access scheme. If there is $T < T_{min}$, implement the process in Step 1.

3.3 Repeated Game Analysis

The new OP includes setting $p_i |g_i|^2$ to be constant α, which is the only solution and able to maximize the expected utility of all city states, could be expressed as:

$$\tilde{\alpha} = \arg\max_{\alpha} E_g[\sum_{i=1}^{N} u_i(\boldsymbol{p})] \tag{12}$$

Thus, the urban resource integration effect value of player i will decline to be:

$$\tilde{p}_i = \frac{\tilde{\alpha}}{|g_i|^2} \tag{13}$$

New OP Pareto will control NE. For player cooperation, we assume that, except for individual CSI assumption, each player is able to know the urban resource integration effect value at each game stage, which could be expressed as:

$$P_y = \sigma^2 + \sum_{i=1}^{N} p_i |g_i|^2 \tag{14}$$

We assume that $p_i|g_i|^2$ setting to be constant α and the urban resource integration effect value might be expressed as:

$$P_y = \alpha \frac{\gamma_i + 1}{\gamma_i} \tag{15}$$

Thus, each transmitter requires SINR of individual and constant α only, so as to estimate the urban resource integration effect value P_y. We assume that the data transfer goes through the decline cities, and the city gain $|g_i|^2$ is within the compact set $[v_i^{\min}, v_i^{\max}]$, then the range for urban resource integration effect value will be expressed as:

$$\Delta = [\sigma^2, \sigma^2 + \sum_{i=1}^{N} p_i v_i^{\max}] \tag{16}$$

Since players are able to detect the change of urban resource integration effect through the deviation of cooperation plans, in fact, when implementing the new OP, the urban resource integration effect is constant and equal to $\frac{\sigma^2(\tilde{\gamma}+1)}{1-(N-1)\tilde{\gamma}}$, therefore, if there is any player deviates the new OP and makes the OP quantity change, the deviation will be detected.

4. Experiment Analysis

In the premise of customer satisfaction and in order to provide related cities with same profit, to promote the comprehensive competitiveness of resources and strategic level of cooperation, the urban resources are determined to be integrated. During verification, the demand for activity ability on resources of the city will be 0.76 (all data in the Section has been subject to identification of unit and normalization); the demand for activity ability on 3PL resources is 0.65. The basic operation parameters of integration of each resource individual are shown in Table 1 and Table 2. Resource integration consultation will be made on outsourced resources integration and 3PL resources integration respectively. The discussion below is designed to describe the basic idea about integration decision made in the Article, and the effectiveness, feasibility and flexibility of the algorithm.

Table. 1 Operation parameters of integration of outsourced resources in service-oriented city network

Operation Parameters	Outsourced individual 1	Outsourced individual 2	Home-grown
Integration cost C	0.46	0.67	0.13
Time limited tolerance θ	0.43	0.27	0.73
Activity ability	0.65	0.88	0.80

Table. 2 Operation parameters of integration of 3pl resources in service-oriented city network

Operation Parameters	3PL individual 1	3PL individual 2	3PL individual 3
Integration cost C	0.46	0.67	0.13
Time limited tolerance θ	0.43	0.27	0.73
Activity ability	0.65	0.88	0.80

Upon integration, time limit of optimization actions is preferred. During algorithm operation, the parameters are chosen as α=0.3, β=0.5, γ=0.2, ξ=0.1, and the batch of resources integration value is set to be 100, the convergent trend of simulation results is shown in Figure 1 and 2. We can see from Figure 1 that: for outsourced resources integration, since there is no other mission implemented at the feasible domain node (outsourced individual 1, 2 and home-grown) and there will be no action congestion. Thus, after operation of several batches, it will achieve stable state. Almost all resource integration value chose outsourced individual 2, the reason is that though integration cost on such individual is high, its time limited tolerance meets basic requirements of the production/service actions, which is significant for the city to implement product service system quickly, promote customer satisfaction and to implement the leading market strategy. We can also see from Figure 1 that: the quantity of resource integration value through home-grown actions has a trend of rising then falling, that is because with the low integration cost of home-grown at the beginning attracted a large number of resource integration value, when operation batches increased, the quantity of resource integration value will be subject to the control of time limited tolerance, that is why it declines, it also indicates the algorithm flexibility in operation of the complex process for multi-target resource integration.

As shown in Figure 2, the results of 3PL resource integration computing are that most of them chose 3PL individual 2, the reason is that such individual has obvious advantages on time limit. However, though the activity ability of such individual could be guaranteed, some resource integration values chose 3PL individual 3, because as compared with 3PL individual 2, such individual has greater advantages on integration cost, which means the integration decision making process must consider the coordination and balance among multiple targets, so we can see that such algorithm has better flexibility in this respect.

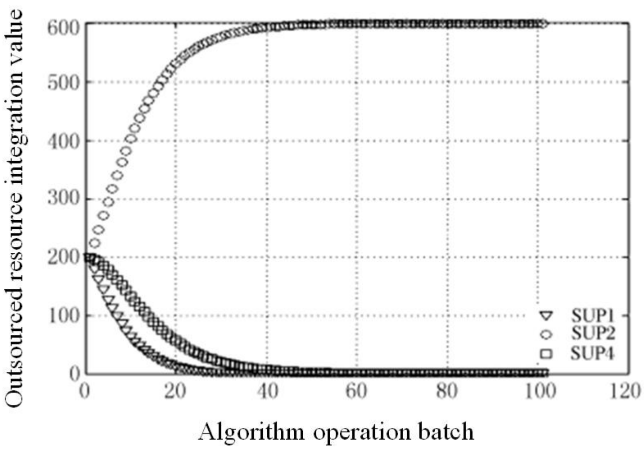

Fig. 1 Schematic of simulation results converge trend of outsourced resource integration

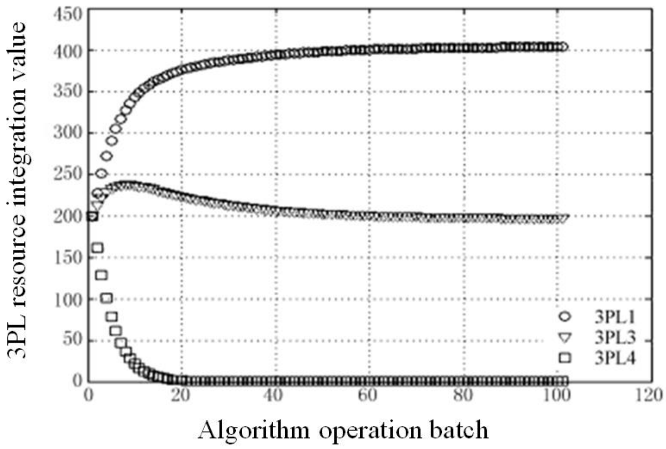

Fig. 2 Schematic of simulation results converge trend of 3pl resource integration

5. Conclusion

An urban resource integration method based on repeated game control scheme is proposed in this Article, which quantifies the operation level of dominant factors and fully considers the hardware and software strength for urban resources integration, designs a optimization model of urban integration decision and applies a repeated game control scheme and achieves overall optimization of the optimization model for urban integration decision. The focus of study in next stage will be the development of an application system for the proposed algorithm.

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