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Cross-Organization Workflow Research of Agile Telecom on Positive Feedback

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Abstract: *In order to promote the core competitive power in telecom operating enterprises that face market fine operations, this article compares ECTA mode (Extension Case Transmission Mode) and LCA mode (Loosen Couple Mode). By comparing LCA mode with ECTA mode, we can find out the conditions, in which these two modes are appropriate. Besides, we can keep the semantics of the public flow mode and do our best to modernize the workflow by improving the task complexity, information transparency and operating controllability of LCA mode through a positive feedback system and by improving ECTA mode through a Petri net system.*

Keywords: *Cross-organization workflow, LCA mode, ECTA mode, positive feedback, Petri net.*

1. Introduction

Since having broken monopoly and brought competition in, the telecom industry in China has encountered competing stages on price, quality, service and business. In the business competition stage, the issue of the operating mode became the focus of the industry, which was a huge transition in telecom industry. During this transition, the boundary of this industry was gradually blurred and even disappeared.

Especially in the next generation of networks, the telecom operators will completely depend on digital technology. Moreover, the abstractness and newness of digital technology will lead to greater invisibility and more openness, so that the organizational boundary will become more blurred and dynamic changes will take place. Especially in cross-organization commercial environment, proper information sharing between providers and consumers determines the success of the commercial flow contraction and commercial cooperation based on a network [2, 13]. Hence, it is necessary to combine the data flow view and flow model [14]. In order to provide satisfactory products and services to customers, we need to integrate the entire value chain (network) of various partners. The key factors that decide the destiny of cooperative enterprises are the sensitivity and fast-responsibility of the cross-organization flow. Lean Operator is one of the telecom enterprises with an improved operating mode, which includes the following features: enterprise strategy oriented at customer needs, focusing on flow-type organization construction on life cycle of products, integrating internal and external resources of enterprises with soft business mode and dynamic workflow technology, providing telecom service products of high efficiency and personalization for users.

Zisman was the first one to put forward the concept of a workflow. At present, Workflow Management Coalition has formally defined that workflow is the entire or partial automation of the business flow based on a computer. The support from the workflow technology to cross-organization flow is based on the interoperability of the workflow system, which means that there is a workflow engine for every cooperative partner which does a series of interactions through the request response. At present this kind of interoperability still remains with loosely coupled flows between organizations. That is to say, it is not established on a shared cross-organization flow basis, and it is related with the organizational modes between enterprises. Workflow stands for the commercial flow in organizational environment [3]. The modelling of the workflow involves some basic factors, for example, activity/commission, working case, resource, character, data element/document, status information and restriction, etc. [1]. The angle of the function emphasizes on commission types and executing reason. The angle of behaviour involves in the time to execute the task (shown in order), which describes the condition/principle of the task order in controlling the workflow: control flow. The angle of organization pays attention to "which resources will be involved in the executing task". The angle of information focuses on the data that the task needs to read and produce during the executing process of workflow, which angle is related with the data flow [6].

2. Comparative evaluation of ECTA and LCA

Van [15] has identified six interactive operation patterns among the workflows. Among them, Extension Case Transmission Mode (ECTA) and Loosen Couple Mode (LCA) modes have become the major workflow modes in cooperative business contexts because of their greater flexibility. Therefore, for the functional design of the electronic business presented by NGOSS system, ECTA and LCA should be considered.

2.1. Extended case transfer architecture

Under ECTA mode (see Fig. 1), all business partners have the same flow definition and different business partners can define local variables according to their own situation when performing their duties, for example, in certain situations, the flow may be extended to other tasks that should be completed before transferring the case [6].

Under this mode, although the co-operators share the same flow version, it does not mean that every operator can handle all tasks. A case is the information set to transfer information between the organizations [7]. This can mean a case about one flow, or about the whole workflow. The partners decide the time and target cooperative partners to transfer a case according to the "transfer protocol" [8]. During the cooperating process, the information is shared and the working result can be reflected in the cases transferred.

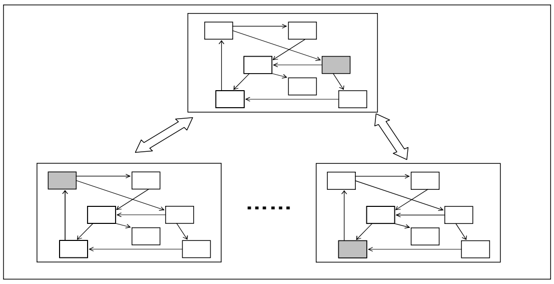

Fig. 1. (Extended) Case transfer architecture

2.2. Loosely coupled architecture

Under Loosely Coupled Architecture (LCA) mode (Fig. 2), the workflow can be divided into several parallel blocks, and each sub-flow is defined locally [9]. For the whole collaborative environment, we do not need to understand the specific sub-flow and just need to manage the communication protocols that are defined and negotiated by the cooperative partners. This model enables several process cases to run in the respective execution environment mutually and independently. However, it requires the existence of a synchronization point in each process. When each of them runs to the synchronization point, it will trigger an event. This mechanism can be used to achieve many functions, such as scheduling a parallel execution thread, restoring a data check or transferring the workflow data in different process cases.

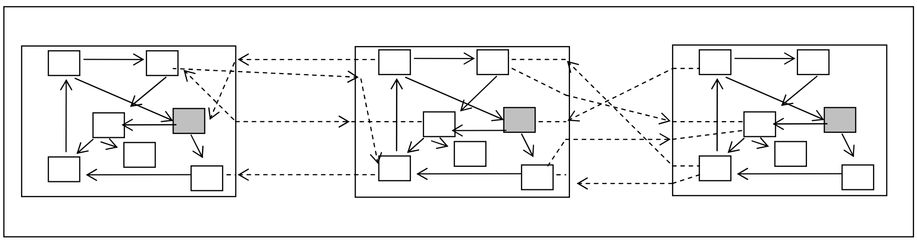

Fig. 2. Loosely coupled architecture

The essential difference between ECTA and LCA is that they have different division towards tasks: the former is longitudinal, depending on the case to transfer information, while the latter is lateral, relying on a protocol to transfer information. If we compare the adaptive degree of these two modes from the coordinative angle among enterprises, we can see their advantages and disadvantages more clearly. The following table is the result of comparing the performance of these two modes based on Table 1.

Table 1.Comparison of the advantages and disadvantages between ECTA and LCA

Comparing item	ECTA	LCA
Prior cooperative degree	High	Low
Cooperative degree while operating	Low	High
Complexity of the whole task	Medium	High
Transparency of information	High	Low
Complexity of information	High	Medium
Smooth feature of the task	Low	High
Controllability of the task	High	Medium

As we can see from Table 1, LCA has great advantage with respect to the cooperativity and flexibility in cooperation; if compared with ECTA, the combination among the organizational members is loose. Hence, we can conclude that under cooperative business environment where the mature cooperation and work mode is relatively firm, it is suitable to adopt ECTA mode, for the information transparency is low and the task smooth feature is weak, so that they can be realized by tacit relationship formed long-term and low requirement on the cooperative flexibility. But under the cooperative environment, where the product cooperation is strong, the work mode life cycle is short and the cooperative partners are not fixed, it is more suitable to adopt LCA mode and improve it through a positive feedback system.

3. A positive feedback system improving LCA mode

The evolution process of a positive feedback is related to the status intensity. Since it can lead to different roads and results, this positive feedback which is more adapted, prior and smooth seems process related to the experience, which can be described in Polya process [10]. As for the task complexity of LCA mode, the transparency of information and deficiency on the working controllability, we can improve all of them by enhancing the coordination and management function of a core enterprise. For example, enhance the information exchange and knowledge sharing under supervision of the core enterprise that will coordinate and supervise the working controllability. Through enhancement of the above aspects, the coordinative business must be formed into an organic operating system and the task complexity of LCA mode will be greatly reduced. Under the entire coordinative business environment, the core enterprise' role on coordination and supervision will reduce the operating cost among enterprises. The operating cost must have relationship with maturation and experience of the cooperation among enterprises.

Therefore, the positive feedback system can reduce the cooperative cost and improve LCA working mode.

The task complexity, information transparency and work controllability are reflected as kind of an operating strategy, including that of cooperative partners and a core enterprise. Seeking for the best strategy can bring the operating cost in a member enterprise to a reasonable status.

Suppose that there is strategy collection of enterprise operations under LCA workflow mode of cooperative business, which is the centralized performance of information exchange, business cooperative method and control way, these strategies are related with former operating experience and effect.

Suppose that there is a cooperative strategy group under LCA mode, which we can put in *N*–type enterprise operating strategy of the cooperative business and add one new node at once. The strategy attribution of the newly-added node will be fixed according to the probability ratio, which is the function of the specific-gravity vector $X_n = [x_{1n}, x_{2n}, ..., x_{Nn}]$ on the attribution nodes of the added strategy. The probability ratio is related to the intensity of the strategy status, which means to be related with an operating successful ratio and adopted ratio before the strategy.

Suppose that the probability ratio for *i* strategy node, becoming the newly added cooperative strategy group for *n* times is $q_{i,n}(X_n)$:

Accept that the beginning node in the cooperative strategy group is

$$b_0 = \sum_{i=1}^{N} b_{i0}.$$

Then at No time *n* we define:

$$\beta_{i,n}(X_n) = \begin{cases} 1, \text{ Prob } q_{i,n}(X_n) \\ 0, \quad \text{Prob}(1 - q_{i,n}(X_n)), \end{cases}$$

$i = 1, 2, \ldots, N$, so the adding principle of i node is:

(1) $$b_{i,n+1} = b_{i,n} + \beta_{i,n}(X_n).$$

(1) dividing $b_0 + n - 1$, and suppose $x_{i,n} = b_{i,n}/(b_0 + n - 1)$, we can get:

(2) $$x_{i,n+1} = x_{i,n} + \frac{1}{b_0 + n}[\beta_{i,n}(X_n) - x_{i,n}], \qquad n = 1, 2, ..., N.$$

Rearranging (2) we can get:

$$x_{i,n+1} = x_{i,n} + \frac{1}{b_0 + n}[q_{i,n}(X_n) - x_{i,n}] + \frac{1}{b_0 + n}\mu_{i,n}(X_n), \qquad n = 1, 2, ..., N,$$

$$\mu_{i,n}(X_n) = \beta_{i,n}(X_n) - q_{i,n}(X_n).$$

According to the definition of $\beta_{i,n}(X_n)$, the expectation value of $\mu_{i,n}(X_n)$ is zero. So we get that the expectation value of the stochastic process is:

$$E(x_{i,n+1} \mid x_{i,n}) = x_{i,n} + \frac{1}{b_0 + n}[q_{i,n}(X_n) - x_{i,n}].$$

It equals the certainty recurrence process, that is

(3) $$x_{i,n+1} = x_{i,n} + \frac{1}{b_0 + n}[q_{i,n}(X_n) - x_{i,n}], \qquad i = 1, 2, ..., N.$$

In (3), $q_{i,n}(X_n)$ is generally nonlinear, which is related to the proportion of the various strategy node, or we can say it is related with the proportion strategy adopted. Formula (3) stands for kind of a nonlinear Polya process. The recurrence evolutionary process is controlled by the second item $q_{i,n}(X_n) - x_{i,n}$. For *1*＝1, 2, …, *N* kinds of strategy nodes, there are *N* equations sets. If we use a vector to illustrate, we have:

(4) $$X_{n+1} = X_n + \frac{1}{b_0 + n}[q_{i,n}(X_n) - X_n].$$

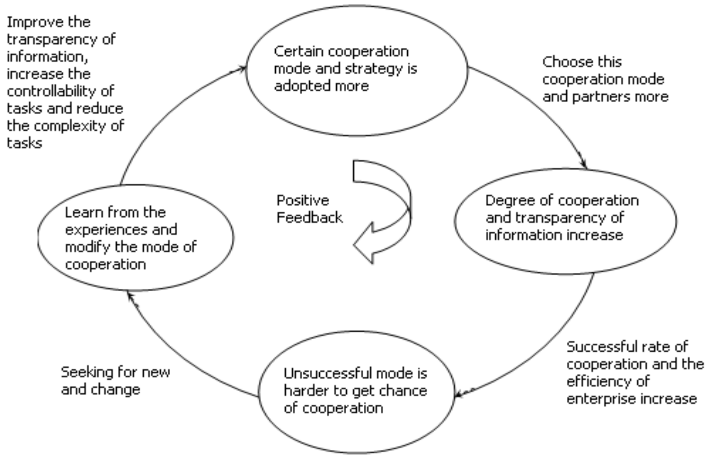

Fig. 3. Illustration of the positive coordinative system of LCA mode

The pattern of $q_{i,n}(X_n)$ will change *n* times. If the speed q_n constricts to a certain function *q* in a fixed pattern faster than that of $\frac{1}{b_0 + n}$ constricts to zero, this means that the speed $\frac{1}{n}$ constricts to zero while *n* becomes larger. Then the fixed point vector (the most reasonable intersecting point to meet the operating cost of the virtual enterprise and the whole cooperative business) in (3) will be defined by the following formula:

$$q(X_n) = X_n.$$

If this intersecting point is stable, a nonlinear Polya process will be constricted to this. These kinds of a strategy space and restriction to reduce the operation cost produce a positive feedback effect, as well as the best reflection on the strategy collection of regular permutation and monotone character. This is the basis for a positive feedback system [13].

As we can see from the above analysis, the virtual enterprise is able to adjust itself to the strategy choices according to the evolutionary principle of Polya process and try its best to constrict itself to a fixed point $q(X_n) = X_n$ by using the previous experience. Thus, the strategy implementation can hit the lowest intention on the operating cost within the largest efficiency scope. For LCA mode, this means to enhance the information transparency and task controllability in the shortest time, as well as to reduce task complexity. These factors will be a nonlinear influencing relationship to the strategy choice, but it will reach the best status at the position approaching a fixed point. Hence, we can come to the conclusion: with the improvement of the information exchange way, enhancement of the inter-business knowledge sharing, cooperative business chief's control and coordination towards business operation and trust relationship established with multiple cooperation among enterprises, the disadvantages of LCA mode in a workflow operation will be effectively improved in the positive feedback effect of the above factors. Therefore, the flexibility and fast-response of LCA mode will be better used to make itself out of the best workflow design method of cross-organization to support a cooperative business platform. The feedback recirculating loop of the positive feedback system can be shown in Fig. 3. In applying a positive feedback system to coordinate with LCA mode, the enterprises can apply the strategy given in Table 2.

Table 2. Coordinative strategy adopted by LCA mode

Property	Optimizing methods
Information transparency	Fully apply information technology to complete information exchange ways among enterprises; Strengthen the awareness of inter-enterprise knowledge sharing, improve constructing and managing level on enterprise knowledge; Ensure that there are enough data needed for enterprise cooperation in the member information exchange protocol
Business controllability	Emphasize core enterprise's control and coordination towards overall business; Seek for fast and agile market-responding and business-responding system, apply the cored competitive power of the enterprise and seek for a suitable business mode [14]
Task complexity	The continuous enhancement of the above methods will definitely lead to reducing of the task complexity; The formulating and executing of the task flow will be optimized with the enhancement of the inter-enterprise cooperative ability and mutual trust degree
Result	Inter-enterprise cooperative cost will be reduced, the cooperative effect will be improved, and the cooperative opportunity will be increased. Those that disobey the principle will be gradually eliminated by the union

4. Improvement of the ECTA mode based on the Petri network system

Many results of former studies of the Petri network can be applied to solve these difficulties with ECTA mode [11, 12, 13]. For instance, Aalst's definition of a reasonable Petri network, and research regarding the inherent relations in Petri network evolutions, can ensure that the semantics of the public flow modelling are not lost when optimizing the sub-workflow while being modified by ECTA mode. Based on Aalst's research results, 8 definitions of ECTA and one theory constraining and guiding the ECTA mode modelling process are given below [14].

Definition 1. Three architectures are employed to modify the workflow: iteration, sequential composition and parallel composition. In the conventional language of the Petri network, PP stands for iteration, PJ stands for sequential composition and PJ3 stands for parallel composition.

Definition 2. The workflow network $N = (P, T, F)$ is reasonable, if the following four conditions are true:

1. For any case, the process will come to an end, i.e., there is at least one marked status in the output place.
2. At the time the process ends (i.e., there is at least one mark in the sink place), all other places are empty, i.e., no task is suspended.
3. There is no dead task. In the workflow network, a mark in the original place *i* can execute a random task if obeying a suitable route.
4. The conditions are reliable: they cannot be used many times. That is, the maximum value of a marked number in place is unique.

Definition 3. $N^{\text{pub}} = (P^{\text{pub}}, T^{\text{pub}}, F^{\text{pub}})$, is a WF-net, representing the public (or shared) workflow process.

Definition 4. D is the collection of districts, which represents the business partners in the public workflow. Function $\text{map} \in T^{\text{pub}} \to D$ marks the task of a public workflow on one of the districts.

Definition. 5.

(1) $$p^{\text{exch}} = \left\{ p \in P^{\text{pub}} / \exists t_1, t_2 \in T^{\text{pub}} : (t_1 \in \bullet p) \wedge (t_2 \in p\bullet) \wedge (\text{map}(t_1) \neq \text{map}(t_2)) \right\}$$

is the collection of communicative places: the communicative channel between districts.

Definition 6. The function $\text{inp} \in D \to p^{\text{exch}} \cup \{i\}$ draws each district on the local input function; $\text{outp} \in D \to p^{\text{pub}} \cup \{0\}$ draws each district on the output function.

Definition 7.

(2) $$N^{\text{epub}} = (P^{\text{epub}}, T^{\text{epub}}, F^{\text{epub}})$$

is a WF-net, representing the extension public workflow process.

Definition 8. For any district $d \in D$

(3) $$N_d^{\text{priv}} = (P^{\text{priv}}, T^{\text{priv}}, F^{\text{priv}})$$

is a Petri network, representing the local part in an extension public workflow process. The architecture is as follows:

(4) $$P_d^{\text{priv}} = \{\text{inp}(d), \text{outp}(d)\} \cup (\bullet T_d^{\text{priv}} \cap T_d^{\text{priv}} \bullet),$$

$$T_d^{\text{priv}} = \{t \in T^{\text{pub}} / \text{map}(t) = d\};$$

(5) $$F_d^{\text{priv}} = F^{\text{epub}} \cap ((P_d^{\text{priv}} \times T_d^{\text{priv}}) \cup (T_d^{\text{priv}} \times P_d^{\text{priv}})).$$

Theory 1. Suppose N^{pub}, D, N^{epub}, P^{exch}, N_d^{priv} are defined as above. If N^{epub}, inp and outp exist and meet the following five conditions, the extended sub-workflow is a reasonable workflow that has inherited the characteristics of the public workflow:

1. $N^{\text{pub}} \subseteq N^{\text{epub}}$.

2. For all $p \in P^{\text{epub}} \setminus P^{\text{pub}}$, p is included in $(P^{\text{pub}} \cup d\{p\}, T^{\text{pub}}, F^{\text{epub}} \cap (((P^{\text{pub}} \cup \{p\}) \times T^{\text{pub}}) \cup (T^{\text{pub}} \times (P^{\text{pub}} \cup \{p\}))))$, and there is only one mark of input status in inp.

3. N^{epub} is reasonable.

4. For all $p \in P^{\text{exch}}$, condition $|\bullet p| = |p \bullet| = 1$ is satisfied.

5. For each $d \in D$, N^{privd} are all reasonable.

Under the above conditions: (1) the extended public workflow can only add places; (2) these places should be implicit; (3) no mark is allowed to remain in the implied places while the workflow execution is finished; (4) all transition and place exchange channels are single-directional. The situation is described as follows: there is only one input transition in an autonomous district, so there must be an output transition in another autonomous district. That is, on the same operating hierarchy, the transferred routine of the workflow is unique, and every autonomous district must come to a strategic result at the end. However, this requirement will not restrict the application because the multiple-logic exchange channel is a practical method. The last condition seems similar to conditions (2) and (3). As for division of the public workflow, if there is one local input place and one local output place and the execution of each task can be represented by two place statuses, the local workflow network is reasonable.

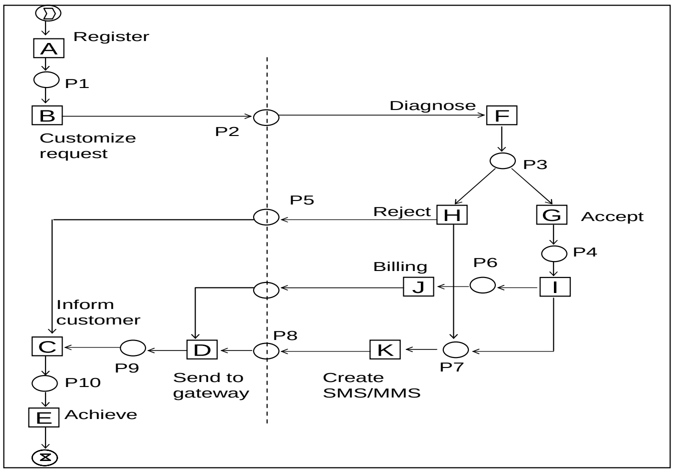

Fig. 4. Workflow illustration during the formulating process

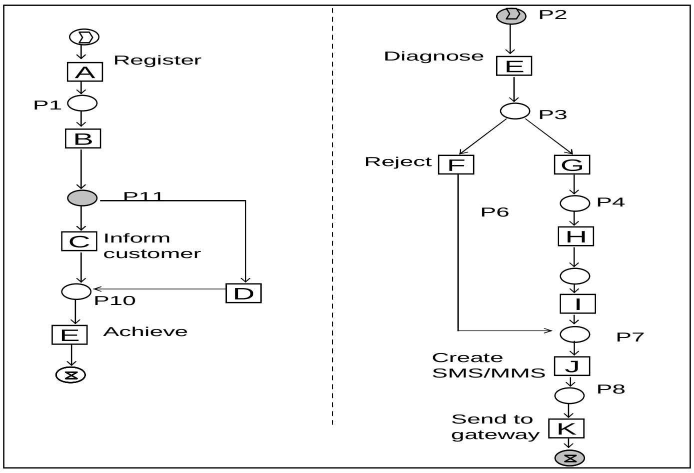

Fig. 5. Distributing illustration on formulating public workflow

5. Conclusions

By comparing LCA and ECTA mode, we have shown that LCA has great advantage in terms of cooperation and flexibility of cooperation. However, if compared with ECTA, the combination among the organizational members in LCA mode is loose and not tight. Hence, we can conclude that under cooperative business environment where mature cooperation and work mode are relatively stable, it is suitable to adopt ECTA mode, for the information transparency is low and the task smooth feature is weak, so that they can be adjusted by tacit relationship formed long-term and low requirement on the cooperative flexibility. However, under the cooperative environment where the product cooperation is strong, the work mode life cycle is short and the cooperative partners are not fixed, it is more suitable to adopt LCA mode and improve it through a positive feedback system.

As for the task complexity of LCA mode, the transparency of information and deficiency on working controllability, with the improvement of the information exchange way, enhancement on the inter-business knowledge sharing, cooperative business chief's control and coordination towards business operation and trust relationship established with cooperation among enterprises, the disadvantages of LCA mode in the workflow operation will be efficiently improved in the positive feedback effect of the above factors. Therefore, the flexibility and fast-response of LCA mode will be better used to make itself out of the best workflow design method of cross-organization to support the cooperative business platform. With modification of the partial workflow in ECTA mode, it will be likely to cause a fatal error in the global workflow. The research on inheritance relation in Petri network evolution can ensure that the semantics of the public flow modelling is not lost and try its best to optimize the sub-workflow while ECTA mode is modifying it.

Certainly, we can adjust and optimize the disadvantages in LCA mode through efficient systems. A positive feedback is just one of them. The others are a nerve network [15], cooperation and genetic calculation. Similarly, in ECTA mode, practical workflow management of the cross-organization may cover many external factors, such as partnership gaming, resource distribution, information integration. In the workflow modelling of cross-organization, these factors should be considered as restrictions. Moreover, some conclusions against Petri network research can also provide optimizing methods to workflow modelling of cross-organization.

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