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Abstract

Purpose – Material conscious and information network (MCIN) is a kind of cyber physics social system. This paper aims to study the MCIN modeling method and design the MCIN-based architecture of smart agriculture (MCIN-ASA) which is different from current vertical architecture and involves production, management and commerce. Architecture is composed of three MCIN-ASA participants which are MCIN-ASA enterprises, individuals and commodity.

Design/methodology/approach – Architecture uses enterprises and individuals personalized portals as the carriers which are linked precisely with each other through a peer-to-peer network called six-degrees-of-separation block-chain. The authors want to establish a self-organization, open and ecological operational system which includes active, personalized consumption, direct, centralized distribution, distributed and smart production.

Findings – The paper models three main MCIN-ASA participants, namely, design the smart supply, demand and management functions, which show the feasibility innovation and high efficiency of implementing MCIN on agriculture. At the same time, the paper presents a prototype system based on the architecture.

Originality/value – The authors think that MCIN-ASA improves current agriculture greatly and inspires a lot in production-marketing-combined electronic commerce.

Keywords E-commerce, Agriculture, MCIN

Paper type Research paper

1. Introduction

1.1 Problems to be solved

In the process of farming and animal husbandry production, management, business and electronic commerce, the relationship between enterprise mainly appears as vertical. There are generally only attachments between adjacent hierarchies. Products are sold through unified platform, dealers, distributors or directly to hotel and supermarket. Nowadays farming and animal husbandry enterprises have the following problems:

- insufficient use of the information of production and business operation process;
- the production and business operation process is not transparent;
- B2B and B2C trading patterns are not diverse enough;

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- the quality of the product does not match with the price; and
- do not have a high level of synergy between enterprises.

Farming and animal husbandry production quality directly affect the public's food safety. Studying how to change the existing hierarchical, enclosed farming and animal husbandry to a self-organization, open and ecological operational system is very important.

1.2 What we want to do?

The best way to solve this problem is restructuring the existing hierarchy between enterprises, reengineering the business process through making full use of current ERP system and the Internet of Things (IoT) designing a novel agriculture architecture. So, we want to establish a new agriculture architecture to realize an agricultural production trading with convenient operation, accurate delivery, intelligent remind, transparent production, dynamic price.

1.3 How to do it?

Material conscious and information network (MCIN) model is a kind of cyber physics social system. With MCIN model, we can map the commodities, individuals and enterprise in physical world to mirror images under the network space, and complete the ternary blend of material conscious and information, also participants can undertake social contact and trading. Based on MCIN model, we put forward the MCIN-based architecture of smart agriculture (MCIN-ASA) to meet our demands. MCIN-ASA refers to the classic software architecture, MVC, and adds the physic layer, which is called PMVC system together.

We divide MCIN-ASA into four layers: the physic layer, model layer, controller layer and view layer. The physic layer includes ERP systems, the IoT devices, animals and plants, which is the source of information. The model layer includes data acquisition, data transmission and data storage. The controller layer is mainly used for undertaking a series of functions in production management and supply–demand matching, including the supply–demand matching based on MCIN addressing method, intelligent production management and intelligent trading methods. The view layer is mainly the user interface, including AR, VR, graphic, video, etc.

First of all, we are going to design MCIN-ASA participant nodes. The design mainly includes the physic layer and model layer. The physic layer defines data acquisition equipment, and the model layer defines data structure of varieties of data. And then formulate supply–demand matching rules and quality-tiered pricing standards in the controller layer and through the addressing method of supply–demand matching between the MCIN-ASA participant nodes provided by MCIN. Finally, cooperated with the user interface which can be called personalized portals, we complete the operation of the whole architecture.

1.4 What can we benefit from this?

- The collection and use of MCIN-ASA participants information can make users complete passive accurate delivery and active accurate transactions through personalized portals.
- Each participant in the MCIN-ASA has an independent intelligent personalized portal. Users can customize the independent portal display form, the information and the behavior way, which increases the propaganda effect.

- Under the internet environment, MCIN-ASA participants trade agricultural products disintermediated and decentralized, which increases the trade efficiency.
- Personalized portals and scenario-based trading work together, improve enterprise competitiveness and also can meet the personalized demands of consumers.

2. Literature review

The MCIN is a large-scaled, open-styled, self-organized and ecological intelligent network. The nodes of the MCIN are information counterparts of supply and demand sides in realistic trading activities or interactions, which can be divided into four categories: person, enterprise, administrative department and thing. Each of the MCIN node has basic and supply–demand information. The basic information reflects the material world of a node, whereas the supply–demand information represents the history of the conscious world of a node (Shen *et al.*, 2017).

MCIN is a cyber-physical system that joins the supply and demand relationship. MCIN has many advantages, such as decentralization and disintermediation. These two features are very important and revolutionary in trading. Intermediation leads to commodity markup, and centralization leads to unreliability of information and unsafety of personal privacy. Decentralization and disintermediation have lessons for all current business models. The authors hope to establish a new intelligent and credible agricultural e-commerce architecture in this paper, and it seems MCIN is very effective.

However, the work of the previous scholar mainly focuses on the basic level, such as how to model it generally. MCIN provides a good idea to implement the ASA, but real-life application scenarios are very complex, so we still need to solve differences in a unified structure.

3. Basic architecture and components

This section mainly introduces the basic architecture and components of MCIN-ASA, including MCIN-ASA nodes structure, function and interconnection.

In MCIN-ASA, each enterprise node has a complete PMVC system, including an enterprise entity, some commodity nodes, the IoT system, the ERP system and a personalized portal. As the owner of MCIN-ASA enterprise node, an enterprise is the physical carrier of the node, so the enterprise itself is a part of the physic layer. MCIN-ASA commodity node is a child node of the enterprise node which also cyber-anima like other character nodes and will be mentioned in the next part. IoT system and ERP system are used as the data source for model layer support. Personalized portal is the carrier of controller layer and view layer. Each portal consists of four parts which are "who am I", "my supply", "my demand" and "my space". It provides enterprise information management, smart demand, demand management, production process traceability, production management, supply management, social management, etc. Due to its peer-to-peer trading, we introduce the block chain technology to guarantee the authenticity of enterprise information, the external data, quality tiered pricing standards. Agricultural types mainly include breeding, cultivation, planting, processing and logistics enterprises. Enterprises will be deployed IoT systems, ERP systems and telematics system to satisfy requirements (Table I).

The ultimate goal of agricultural production is transaction. Agricultural products basically have two costumers: enterprise, individual. MCIN-ASA individual node also has a PMVC system, including an individual entity, IoT wear equipment and a personalized portal. As the owner of MCIN-ASA individual node, an individual is the

physical carrier of the node, so the individual itself is a part of the physic layer. IoT equipment is used for health information acquisition. And personalized portal is the carrier of controller layer and view layer. Each portal consists of four parts which are "who am I", "my supply", "my demand" and "my space". It provides personal information management, smart demand, demand management, supply management, social management, etc.

MCIN-ASA commodity node does not have a complete PMVC system, but it has cyber-anima. The node has only one supply which is itself and is released by other character nodes.

A large number of personalized portals connected with each other by supply and demand relationship, which implements the MCIN-ASA as shown in Figure 1.

4. Material conscious and information network-based architecture of smart agriculture models of agriculture participants

This section mainly introduces the modeling details of MCIN-ASA participants, which is divided into four parts:

(1) MCIN-ASA enterprise nodes.

(2) MCIN-ASA individual nodes.

(3) MCIN-ASA commodity nodes.

	MCIN-ASA enterprises	
PMVC	Carrier	Support
Physic layer	Enterprise entity, IoT equipment, ERP system, stream media equipment	Sensors
Model layer	MCIN-ASA node information, MCIN-ASA commodity nodes, third-party data	Extensive block chain
Controller layer	Personalized portal	Six-degrees-of-separation block chain, smart algorithm
View layer		AR, VR, TTS[a], ASR[b]

Notes: [a]Text to speech; [b]Auto speech recognition

Table I.
Basic architecture of MCIN-ASA enterprises

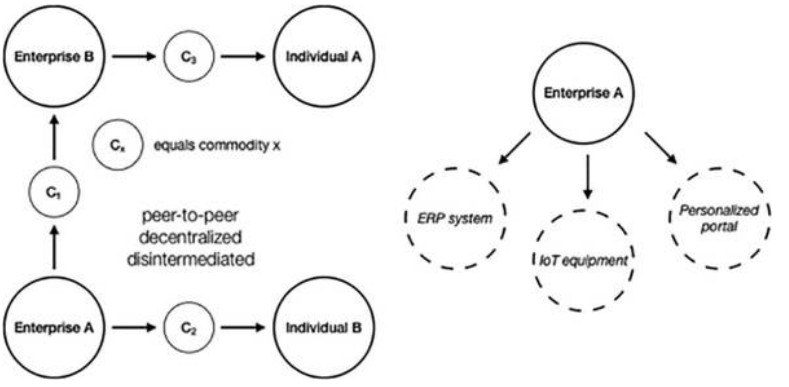

Figure 1.
Supply and demand relationship in MCIN-ASA

(4) Supply–demand interactions between agriculture candidates and how to address.

An MCIN node is modeled based on cyber-anima as tuple A [1] with four attributes:

$$A = \langle I_B; I_S; I_D; T \rangle \tag{1}$$

where:

I_B = is the basic information of a MCIN node;
I_S = is the supply information of a MCIN node;
I_D = is the demand information of a MCIN node; and
T = is the set of time points.

$$I_B = \langle D_{ST}; D_{CH}; D_{EX}; D_{KN} \rangle \tag{2}$$

where:

D_{ST} = is the structure dimension;
D_{CH} = is the character dimension;
D_{EX} = is the experience dimension; and
D_{KN} = is the knowledge dimension.

We will model our agriculture candidate nodes based on the structure above.

4.1 Material conscious and information network-based architecture of smart agriculture enterprise nodes

Through the ERP system, IoT equipment, streaming media equipment and enterprises collect the basic information (identity, display, production and management process information), supply information, demand information, space information to achieve the MCIN-ASA enterprise node's expression (Table II).

Production and operation process information, including the inventory status, production planning, production and operation status, which is acquired from ERP systems and IoT equipment. The supply and demand information of the enterprise mainly describes the demand of the commodity and the history of all transactions. The space information of the enterprise mainly describes and displays the relevant network status, social exchange history information and behavior of the enterprise social interaction (individuals, enterprises, government departments), and we can view the status of the business circle and the government affairs circle, respectively.

The main functions of MCIN-ASA enterprise node are as follow:

- as the carrier and administrator of the MCIN-ASA commodity child node;
- achieving accurate supply–demand matching through information of all dimensions; and
- auxiliary management and decision-making. through docking with the ERP system and IoT equipment's, enterprises can view the production status, be reminded of inventory shortage and accomplish resource scheduling, etc.

4.2 Material conscious and information network-based architecture of smart agriculture individual nodes

Individuals collect basic information (identity, health, nutrition), supply information, demand information, space information, and implement MCIN-ASA individual node's expression through wearing equipment, manual entry, system analysis, etc.

Dimensions	Sub-dimensions	Data or functions
Basic information	Identity information	Enterprise name, business license number, registered address, legal representative, registered capital, company type, registration authority, establishment date, term of business, business scope, etc.
	Display information	Images, videos and VR models of workshop, breeding area or farming area and their production process
	Production process information	The inventory of common raw materials, production operation status, production planning, product inventory, etc.
Supply information		Supply distribution, supply history, supply statistics, current supply, supply forecasting, etc.
Demand information		Demand, demand history, demand statistics, current demand, demand forecasting, etc.
Space information		Network status, social communication history information and behaviors, business circle, government affairs circle, etc.

Table II.
Model of MCIN-ASA enterprise nodes

Nutritional health information can be obtained for the IoT equipment information and can also be entered by the users, including height, weight, protein, fat, muscle, visceral fat, basal metabolism, water, bone mass, blood pressure, blood lipids, blood sugar, sickness and so on. The supply and demand information of the enterprise mainly describes the demand of the commodity and the history of all transactions. The space information of the individual mainly describes and displays the relevant network status, social exchange history information and behavior of the individual social interaction (individuals, enterprises, government departments), and we can view the status of the business circle, the government affairs circle, friends circle and relatives circle, respectively (Table III).

The main functions of NCIN-ASA individual node are to achieve accurate supply–demand matching through information of all dimensions.

4.3 Material conscious and information network-based architecture of smart agriculture commodity nodes

Commodities display the basic information (identity, display, production and management process information), supply information and demand information to achieve MCIN-ASA commodity node's expression, through graphic, AR, VR, real-time video, quality tiered table, etc. (Table IV).

The display information includes the text, graphic, video, 3D models and quality tiered tables. Commodity production and operation process information mainly acquired from the ERP system, IoT system, logistics system, inspection and quarantine equipment, nutritional value information tables, etc. The supply and demand information of the commodity mainly describes the history of the transactions.

By using the information of all dimensions, we can implement some functions:

- real-time automatic updates;
- historical tracing of commodity information;
- quality tiered pricing of commodities;
- more types to display commodities; and
- by analyzing the information of enterprises, individuals and commodities, we can get a smart supply demand relationship.

Dimensions	Sub-dimensions	Data or functions
Basic information	Identity information	Name, gender, age, native place, location, contact information, etc.
	Nutritional health information	Height, weight, protein, fat, muscle, visceral fat, basal metabolism, water, bone mass, blood pressure, blood fat, blood sugar, cholesterol, disease, etc.
Supply information		Supply distribution, supply history, supply statistics, current supply, supply forecasting, etc.
Demand information		Demand, demand history, demand statistics, current demand, demand forecasting, etc.
Space information		Network status, social communication history information and behaviors, business circle, government affairs circle, friends circle, relatives circle, etc.

Table III.
Model of MCIN-ASA individual nodes

Dimensions	Sub-dimensions	Data or functions
Basic information	Identity information	Product name, commodity type, unit, bar code, specification, brand, supplier, origin, freight number, tax rate, retail price, date, etc.
	Display information	Images, videos and VR models of products and their production process
	Production process information	Breeding/farming environment detection information, information processing environment detection, monitoring, inspection and quarantine information, basic information and physiological information, information quality, nutritional information
Supply information		Supply history, supply statistics, current supply, supply forecasting, etc.
Demand information		Demand history, demand statistics, current demand, demand forecasting, etc.

Table IV.
Model of MCIN-ASA commodity nodes

4.4 Supply–demand interactions between agriculture candidates and how to address

There are two kinds of supply and demand matching process in the framework. According to the two sides of the transaction, it can be the divided into business-to-business and business-to-person. But according to the MCIN-ASA nodes, it is divided into commodity-to-enterprise and commodity-to-individual. Because MCIN-ASA's internal nodes have the characteristic of point-to-point, the search process needs to use the nodes' cyberspace structure, that is, six-degrees-of-separation block chain.

Let us say our own node is the source node. Six-degrees-of-separation block-chain chained enterprise nodes and individual nodes that transacted with the source node before. So, when we put forward a need, source node will do parallel recursive searches. And recusing no more than six times, we can search all the nodes in our MCIN-ASA ecological environment. For instance, we put forward a need of chicken legs. First, source node will search in its own block chain. If there are nodes which can provide chicken legs, the commodity nodes will be threw into a stack, and the recursion will continue. If there are no nodes which can provide chicken legs, the source node will search the block chains of these nodes, and the recursion will continue. Until the number of items searched reaches the maximum limit, the recursive search stops.

Although the search process is clear and efficient, the big problem is how to do the supply demand matching in this situation. We will mention it in the next section.

5. Functional concepts

This section mainly describes the main functions in the portal. MCIN-ASA maps enterprises and individuals in the physical world to the cyberspace, so companies can carry out smart management in agriculture production, individuals can carry out smart health management, including recommending and reminding. In addition, portals provide traceable shopping, smart pricing and supply demand matching methods when transaction.

5.1 Smart management in agriculture production

- *Real-time monitoring*: The portal will collect the key data of production and operation process to facilitate real-time monitoring of production and business status online.
- *Alarm system*: Temperature and humidity alarm, disease alarm, death alarm.
- *Procurement reminder*: Through the analysis of production planning, raw material inventory, raw material consumption rate, products inventory status and products consumption rate from enterprise ERP system, portals can provide a procurement reminder service.

5.2 Smart health management

- *Healthy report*: According to the consumer's health information, portal will generate targeted reports and recommendations for reference.
- *Healthy meal recommendation*: The personal consumer portal will recommend consumers to healthy meals by analyzing consumer's health status, preference information and nutrition information
- *Forecasting demand reminder*: The personal consumer portal will provide users with forecasting demand reminder service by analyzing the user's demand history, consumption rate, etc.

5.3 Traceable shopping

When constructing the MCIN-ASA commodity nodes, we add video and virtual reality models of product and its production process, product batch monitoring information and product quality indicators. After shopping, consumers can monitor the whole supply chain and trace back to any detail during production, processing and logistics.

5.4 Smart pricing

Commodity pricing is related to commodity quality. We have put forward the quality tiered table and the quality tiered pricing standards in the early sections.

The quality tiered table contains the quality index of the product, the specific value of the indicator, the index score (0 to 100 points) and the importance (1 to 10, 10 levels). We take the weighted average as the final score. The price is positively correlated with the score.

5.5 Examples and prototype implementation

This part will show some key function pages of MCIN-ASA prototype application as shown in Figures 2-6.

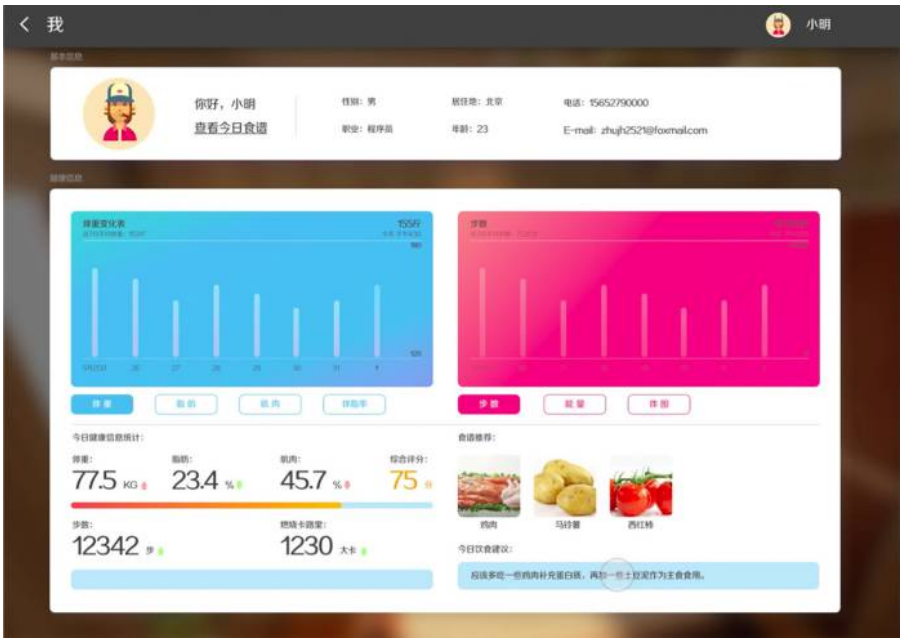

Figure 2.
Basic information page (individual)

6. Conclusion and future work

This section will summarize the breakthrough and promotion of MCIN-ASA:

- We use the full range of information to design the MCIN-ASA participants, which greatly enhance the realism and credibility between enterprises, between enterprises and consumers and between consumers and commodities in cyberspace.
- We establish the personalized portal for enterprises and individuals to enhance the convenience during production process and the process of consumer spending.
- The point-to-point precision interconnection between enterprise and consumer personalized portals, intelligent transactions, process tracing and credible technology based on the block chain enhance the synergies operating efficiency and quality between enterprises.
- We price commodities by analyzing the objective-big-data-based product quality information, which realizes the value of commodities and enhances the economic and social benefits of enterprises.
- MCIN-ASA is a self-organizing, open architecture that facilitates decentralized production and business development.

We intended to continue our research in the following parts:

- improve the traceability shopping process;
- further study and implement the quality standard pricing standards;
- implement MCIN nodes recommendation algorithm; and
- enhance the reminder and alarm function.

Figure 3.
Supply information page (individual)

Figure 4.
Space information page (individual)

Figure 5.
Production process management page (enterprise)

Figure 6.
Production process information page (commodity)

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Further reading

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