Adaptive Control of Power Supply and Environment Monitoring System Based on Hierarchical Search Engine Tactics

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***Abstract* – The paper presents an adaptive scheme to control a power supply and an environment monitoring system using hierarchical search engine tactics. Based on a nonlinear parameters control model of a dynamic environment and coupling characteristics, an adaptive control strategy is devised using hierarchical search algorithm to build a fast and scalable policy implementation model. A monitoring system based on cloud service is normalized into XML data streams sent to remotely control host nodes. Theoretical analyses, simulation and real environment test results show that hierarchical adaptive search engine strategy is better than common ring control system and gives more flexible control method with less overshoot and more scalability. Not only does the central monitoring system offer good application potential, but it can also be seamlessly extended to others sub-systems in the environment.**

Keywords -- Dynamic environment monitor; Search Engine; XML; Control strategy

I. INTRODUCTION

Power supply and environment monitoring systems form the basis of centralized monitoring systems for power and environment, using remote sensing, remote adjustment, and remote control technology, such as centralized scheduling, monitoring, analysis and data processing of intelligent systems. At present, in the field of power supply and environment monitoring, there has been some research on the control strategy. Among them, is involved mainly in hardware architecture and control strategies (control algorithm) [1]. At first this paper references some environment monitors and control system based on fuzzy control strategy, then it gives an adaptive control strategy [2, 3]. After XML normalization of data flow based on adaptive control strategy, the cost of control is considered leading to the use of low cost ARM chip. Because of the limit of resource of low cost chip, this system uses an optimized search algorithm in Adaptive control strategy based on hierarchical search algorithm. [4, 5, 6]. System was evaluated using substation systems. Test results show the optimized algorithm for model offer scalability and has broad application potential.

II. BASIC MODEL OF CONTROL STRATEGY

System of this paper is to measure multi-sensing device based on sensing device linkage control sample data output of complex systems, nonlinear, time-varying, delay, uncertainty and multiple goals, control parameters of mutual coupling between a strong, strong time-dependent characteristics. Therefore, the traditional control strategy is difficult to implement in the system.

Is currently more common control strategy based on fuzzy control theory, more common is the single-input and single-output system [3]. But for complex control systems, often encountered strong coupling of multiple-input multiple-output system.

Power supply and environment complex monitoring systems, multi parameter controlling the rules are growing exponentially with increased sampling, control rules of fuzzy controllers will become too complex and difficult to control. In the case of multivariate control rules need to be adaptive in order to improve the efficiency of operating rules.

Fuzzy controller for multiple-input multiple-output, its rules have the following form:

$$R = \left\{R^1_{MIMO}, R^2_{MIMO} \cdots R^n_{MIMO}\right\} \quad (1)$$

Among them, R^i_{MIMO} : is direct product space $X \times \cdots \times Y$ of the fuzzy sets. They are independent of each other. So, rule i R^i_{MIMO} can be expressed as the Fuzzy implication relation:

$$R^i_{MIMO}: (A_i \times \cdots B_i) \rightarrow (A_{i1} \times \cdots B_{iq}) \quad (2)$$

Control strategy of R^i_{MIMO} can be expressed as:

$$\begin{aligned} R^i_{MIMO} &= \{(A_i \times \cdots B_i) \rightarrow (C_{i1} \times \cdots C_{iq})\} \\ &= \{[(A_i \times \cdots B_i) \rightarrow C_{i1}], \cdots, [(A_i \times \cdots B_i) \rightarrow C_{iq}]\} \\ &= \left\{R^{i1}_{MIMO}, R^{i2}_{MIMO} \cdots R^{iq}_{MIMO}\right\} \end{aligned} \quad (3)$$

Therefore, the rules r can be expressed as:

$$R^{i}_{MIMO} = \left\{ \bigcup_{i=1}^{n} R^{i}_{MIMO} \right\}$$

$$= \{ \cup_{i=1}^{n} (A_1 \times \cdots B_1) \rightarrow (C_{i1} \times \cdots C_{iq}) \} \tag{4}$$

$$= \left\{ \bigcup_{i=1}^{n} \{ [(A_1 \times \cdots B_1) \rightarrow C_{i1}], \cdots, [(A_1 \times \cdots B_1) \rightarrow \right.$$

$$\left. \rightarrow C_{iq}]\}(A_1 \times \cdots B_1) \rightarrow (C_{i1} \times \cdots C_{iq}) \right\}$$

$$= \{ R^{1}_{MIMO}, R^{2}_{MIMO} \cdots R^{q}_{MIMO} \} \tag{5}$$

Obviously, rules r can be considered as composed by q rules, each rule n-multiple-input and single-output rules. Because the rules are independent of each other, so in control of complex multiple-input multiple-output system into subsystems of the single rule of fuzzy reasoning. One article I was by MIMO q independent rules r rules [7]:

$$R = \{ R^{i1}_{MIMO}, R^{i2}_{MIMO} \cdots R^{iq}_{MIMO} \} \tag{6}$$

Adaptive control strategy is the core of dynamic control system, dynamic loop monitoring sensor, the more important the sensor parameters such as temperature, humidity, power control, one of the effects of temperature and humidity is the most obvious, so the system specific research on temperature and humidity. Control system of temperature and humidity in the greenhouse environment is a multiple-input multiple-output (MIMO) Adaptive control strategy of Adaptive adjustment in a number of different sensors, into a multiple-input and single-output (MIS0) mode, using multiple MISO instead of MIMO control rules of fuzzy controllers, fuzzy control rules to reduce, simplify the controller design.

Temperature and indoor temperature and humidity control with relative independence, so the system temperature and humidity controller to solve a number of input control rules caused by excessively large problems. The following analysis on temperature control of fuzzy controller for greenhouse system build process.

III. ADAPTIVE CONTROL STRATEGY DESIGN

Establishing model adaptive control strategy basic rules are based on different scenarios of different control strategies when error or higher, select a control to eliminate the error as soon as possible; and when the error is small, the selection control to prevent overshooting, to the stability of the system as the main point of departure. According to the above principles and different requirements in different scenarios are dynamically adjusted in real time to changes in temperature and humidity, in table 1 below are specific instances of a control strategy.

TABLE 1. SYSTEM CONTROL STRATEGY

Control Name	Function
Artificial control strategy	User manual control through the management system controlling equipment operation status
Control strategy based on equipment	According to the set temperature and humidity control system, based on the device type unit to control system
Control strategy based on room	Can be set to different rooms with different temperature and humidity control requires, under the management of the room, in room of all regulation equipment
Control strategy based on server	Server using historical data, based on neural network compensation control model of more complex control systems

In different scenarios, dynamic discrimination control strategies, demand different Adaptive dynamics into the appropriate control strategies. XML Repository generated mechanism of adaptive control strategy special databases. Taking into account the dynamic control system to control ARM host hosting is cheap, so based on adaptive control strategy need to be further optimized search algorithm. Therefore, the system has generated XML data flow control strategy based on hierarchical search algorithm, to further ensure the efficiency of search.

IV. XRDS ENGINE MODEL

In view of the above analysis, this paper has XML data of control strategy to build a search engine. XRDS engine is used in the literature [6], XRDS in order to resolve the ambiguity of the word, introducing ontology, similarity between two documents from the vector space model (the Vector Space Model, VSM) is calculated. Minimum description length (Minimum description length, MDL) decided the simplicity of the search results, in addition, in order to improve efficiency, introducing XML with incomplete information tree.

XML document model database consists of DTD (Document Type Definition) as the main form of pattern files, store all the schema files. Each DTD file stored in "XML database document mode", you can access over the Internet.

When the control unit starts, will produce two memory control information tree, two special data XML repositories, one in memory of incomplete information strategy, a comprehensive information strategy library on your hard disk.

When the controller receives sensor sampling information, search engine based on incomplete policy information that tree in memory to determine whether outputs can be controlled. When storage space has had on the search for information, the rules in use of the storage space information to accurately control output information. When storage space is not about the search for information, or incomplete information about the search time, based on information that is already generating more efficient, non-redundant query conditions into the hard disk continues to search for complete enriched control strategy. This will not only improve search efficiency, meet the accuracy of searches under different scenarios.

Search parts can be divided into three parts which are described as "input module", "output modules" and "timing control module". "The device input" and "output control module" can be mapped into a binary n-dimensional vector, where n is the number of terms in the glossary. Reset a user model you want to query for the u. Each DTD file in the database as DTD_i. U and DTD_i respectively [8,9]:

$$U = (w_{u1}, w_{u2}, w_{u3}, \cdots, w_{un}) \tag{7}$$

$$DTD_i = (w_{i1}, w_{i2}, w_{i3}, \cdots, w_{in}) \tag{8}$$

Among them, the vector $w_{uj} (1 \le j \le n)$ is set to 1 or 0, if a DTD, an element and t-th element in the vector, the vector w_{it} is 1, otherwise 0. Similarity between u and DTD_i each DTD file is calculated as [10,11] :

$$Similarity(U, DTD_i) = \frac{\sum_{j=1}^{n} w_{uj} \times w_{ij}}{\sqrt{\sum_{j=1}^{n} (w_{uj})^2 \times \sum_{j=1}^{n} (w_{ij})^2}} \tag{9}$$

In order to calculate the user the requested mode and after each change in the database document similarity between models, if the similarity is 1. The two identical patterns; if the value is 0, and two pattern completely. Larger values, two patterns similar to smaller values, the greater of the two mode. Due to $w_{uj} (1 \le j \le n)$ be 1 or 0, so the two models cannot be negative. Similarity the largest pattern is most in line with user requirements. Users specify a threshold $r (0 \le r \le 1)$, $Similarity(U, DTD_i) \ge r$, model DTD_i included in search results.

V. MODEL IMPLEMENTATION

In order to define model node in cyberspace, the model node in the system is functionally divided into 4 layers, each layer is responsible for a search space, as shown in Figure 1.

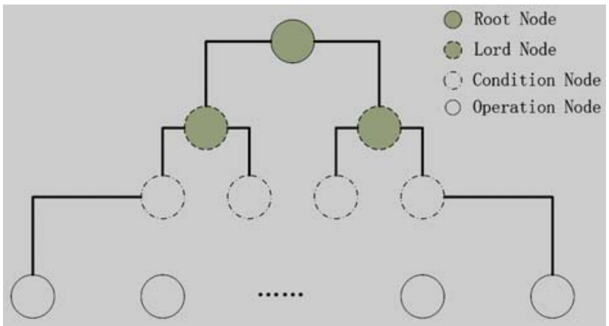

Fig. (1). Node Space Model

Following is a model of space classification nodes:

Root Node: In a model of the highest level, is responsible for storing the entire system of global information, such as IP address list rules, adaptive strategies of indexing information, spatial configuration information.

Lord Node: In a model of the 2nd layer, responsible for storing information within their own jurisdictions, such as sensors in the region resource index database, the complete rules of XML information database, and in order to enhance information retrieval efficiency generated is incomplete policy rules, such as, directly responsible to the Root Node, received from the upper level of the retrieval request returns the search results.

Condition Lord: Located in the 3rd layer of the model, is responsible for running the conditional policy index is built, and Lord synchronize Node, the sensor on the mechanism of information corresponding to the conditions for strategic decision of judge conditions.

Operation Node: In the model on the 4th floor, generally under the condition output action trigger mechanism in the Lord. The node implementation mechanisms will be based on different scenarios, information index will vary. Directly output in simple situations, in order to improve the efficiency of cache mechanism in complex scenes, there is another implementation of polling the state machine implementation.

Taking into account the power supply and environment monitoring system for the complex nature of the environment, and speed of retrieval is not a centralized search engine. In order to solve the speed of retrieval problems, introduced the concept of asynchronous retrieval in the model.

(1) The power supply and environment monitoring server according to the user's configuration corresponding to different scenarios generated complexity of different adaptive strategies, these strategies are then generated in the XML data stream sent to the control unit.

(2) The control unit will parse XML, under the Root Node address information, as well as Lord in node indexing information is not complete in the policy table is mapped to memory, and then under the Root Node a node

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request retrieves the address information for each node, and set the system response time.

(3) The control unit based on sensor nodes sampling Condition Node's own local index database of information retrieval, the search result is stored in the cache.

(4) According to set the response time to the Operation in the Node table search execution strategy, such a retrieval request delivered in the search space.

(5) Multithread technology to collect individual sensing nodes returns data, taking into account the control host cheap, in order to prevent the memory from taking too much causing system instability, so Lord after the action on the Node's index database is updated, this ensures the timeliness of results, also guarantees a high response time and improves retrieval speed.

Typical XML data instance is configured in the system as shown in table 2:

TABLE 2. XML DATA EXAMPLE

```
<config name="init">
   <interval type="sec">1</interval>
   <redoMax>2</redoMax>
   <cmdpair id="1">
         <send>CC06341040AA</send>
         <rec>55073410032A33</rec>
   </cmdpair>
   <cmdpair id="2">
         <send>CC06021072AA</send>
         <rec>55070210015E33</rec>
   </cmdpair>
   <cmdpair id="3">
         <send>CC06331041AA</send>
         <rec>55073310032B33</rec>
   </cmdpair>
   <cmdpair id="4">
         <send>CC06011073AA</send>
         <rec>55070110015F33</rec>
   </cmdpair>
</config>
```

Send and REC node in the configuration file form the pair asked messages to, respectively, sent messages and query node that corresponds to the response message. Cycling query events section is the main part of the implementation of the system, mainly provided for polling nodes in the system order and order interval information. If your system has 4 nodes, to 1 per second polling operation, operation configuration is shown in table 3.

Information message analysis is in line with the cycle a dictionary's section of the event, namely provisions on iterative query message the answering message format. Analytical procedures will be based on the analysis of partial feedback information of nodes is monitoring of all node information.

System installation configuration section is the description section of the control strategy of substation, to describe the most complex part of the system. Configuration contains node information, control strategies, and so on.

Node information section contains this node's address, location information, the initial state. Control strategy part is the description of alarm and control in parts of the system, contains a status sequence, trigger description, operation, monitoring condition description sections. State sequences containing the State of each node can be described.

TABLE 3. XML OPERATION CONFIGURATION

```
<config name="timeEvent">
   <interval type="sec">1</interval>
   <space type="sec">1</space>
   <cmdlist>
      <cmd>CC06342030AA</cmd>
      <cmd>CC06022062AA</cmd>
      <cmd>CC06332031AA</cmd>
      <cmd>CC06012063AA</cmd>
      <cmd>CC06432021AA</cmd>
   </cmdlist>
</config>
```

Trigger conditions using a structured way of describing the logical operations such as AND-OR-INVERT. Detection part describes the conditions if you need to detect whether the after trigger command successfully implemented that achieve the desired results. Operational information the description section describes if the trigger condition is met when the need for action when required to send the message. Program resolved according to parse the dictionary to get the field information, describes according to trigger structure of logical operations, determining operational requirements are met.

TABLE 4. XML TRIGGER CONDITION

```
<con>
   <condition>
      <and>
         <arg name="3" type="lt">5</arg>
      </and>
      <operate>1</operate>
   </condition>
   <condition>
      <and>
         <arg name="3" type="in">6-24</arg>
         <arg name="2" type="gt">10</arg>
      </and>
      <operate>2</operate>
   </condition>
</con>
```

Triggers can be divided into sequences, or key sequence, a sequence of three forms, sequence or with or between non-logical operations. Arithmetic operator is resolved in the dictionary field.

If the node type is 0x01, contains 5 fields of information, trigger condition field [3] <5 triggering action 1, 6<= field [field 3] <24 && [2]>10 trigger operation 2. Results as shown in table 4.

As noted above, after the trigger action can be based on historical analysis of field information in a follow-up operation to analyze whether the operation has completed. Meanwhile, in order to be able to support based on different node address feedback message for testing. In this section of the node ID attribute information is added to the structure. The remaining structure identical to the trigger parts.

Operation information in the description section describes above is triggered when the conditions are met, needs to send the message. Also note that is, operation of the device according to the present state in which to determine the final action. Device trigger an action of type 0x01 1 o'clock, the device address 0x12 and current status of 1, set the new State of the device is 2 sending interval is 60 seconds. You can configure the trigger action information, implementation of the XML output as shown in table 5.

TABLE 5. XML ACTION OUTPUT

```
<operate>
  <op id="1">
    <state id="1">
      <equip addr="12">
          <send>CC08124002012DAA</send>
          <receive>5508124002011B33</receive>
          <setState>2</setState>
          <redoTimeDelay
typ="sec">60</redoTimeDelay>
          <maxRedoTime>5</maxRedoTime>
      </equip>
    </state>
  </op>
</operate>
```

VI. SYSTEM ANALYSIS OF INDICATORS AND PERFORMANCE TESTING

For an assessment of the performance of the model, we set up a test environment for performance analysis, as shown in Figure 2.

System uses the topology as shown in the figure, cloud hosting in the control centre, using the 2.4GHz clock speed of the CPU, 2G IBM server memory, and remote control via Ethernet node hosts interact control nodes using low cost ARM9 core. The control unit as shown in Figure 3.

Sensor node used of is temperature humidity module and power control module, control node through 485 bus collection sensor node of data, cloud host by operation personnel according to different scene prepared control strategy, then by cloud server according to different application scene of complex degrees generated contains control strategy information of XML file, then will this XML file issued to ARM control node host in the, control node host used level search algorithm for traverse sensor node information, More XML and corresponding control policy in action, such as opening a refrigeration compressor, or turn on the dehumidifier.

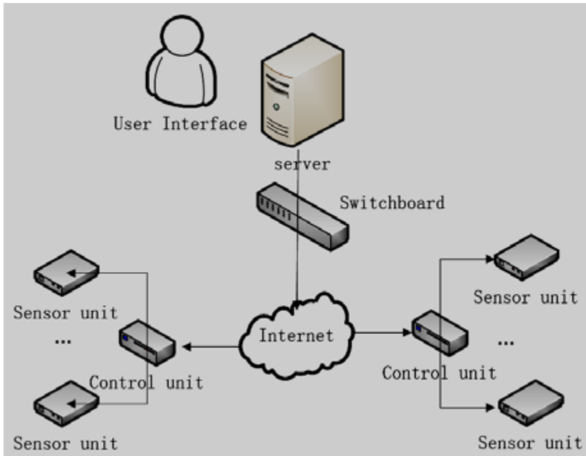

Fig. (2). System Test Topology

Fig. (3). Control Unit

In addition, adaptive control system, also allows the system to some extent with the control strategy, organization and management. For example, when a control using the control strategy based on equipment, the room can be set under one or more equipment for the exclusion referred to the artificial control strategy for management or control room based on a device in the system policy or control strategy based on room and control room b with high fineness requirements, server control strategy to control the whole system. Through a flexible combination of different control strategies, you can make systems controlling particle size smaller, more flexible system.

System test environment consists of 12 rooms, a total of 26 air conditioner units, 33 dehumidifier, and arranged 88 sensor nodes. Control center used a control ARM node host, for the results of numerical simulations, using another host not optimized node control. Experimental results from a packet loss rate of the sensor node number as well as the actual CPU load curve effect, measured the effect as shown in Figure 4.

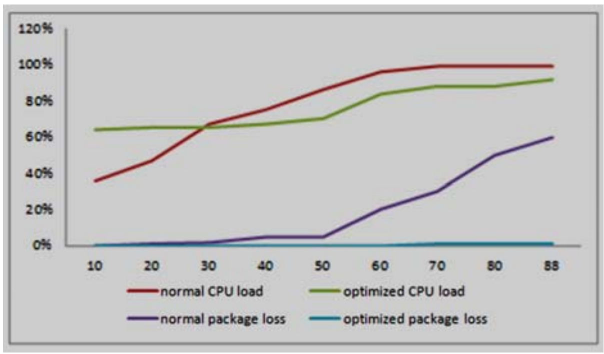

Fig. (4). Packet Loss Rate, CPU Load and Sensor Node Curve

According to the results shown in Figure 4, when testing circumstances, when the number of nodes less CPU load there is no algorithm to optimize of conventional control host takes up less CPU load, and consume more CPU optimized control hosts, this is because after the optimization strategies used in the initialization takes up more memory space and CPU resource. However, when the number of nodes increases, the General controller's workload as the number of nodes increases, especially when the number of nodes exceeds 50 o'clock in routine control of host CPU load will soon rise and exceeds the optimized control host and packet loss rate is soaring. Optimized control hosted in didn't change significantly as the number of nodes increases.

VII. SUMMARY AND CONCLUSION

The paper proposed an adaptive control scheme based on hierarchical search engine strategies of power supply and environment monitoring system. The system contains interactive kiosks, cloud server, control node host, and Terminal-sensor in four parts. Scenario are configured by operations staff through interactive kiosks, a cloud server process an adaptive control strategy to generate XML data streams, which are then sent to the ARM control node host, based on hierarchical search algorithm which can be run unattended.

In the above test results, timeliness and speed of retrieval of the model in the system meet the design requirements. Model through regional accountability mechanisms solve the traditional ring hosts search timeliness issue through this mechanism improves retrieval speed of the system, and once in a site configuration can be easily copied to other similar system. Adaptive strategies used by search engine design and technology framework makes it is an efficient ring system, economic model was applied. This model is adjustable and can be combined. And judging from the actual test results, the system can provide more sophisticated, flexible and reliable. This systems which used this strategy and search engine will have good practical applications.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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