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A decentralized, flat-structured building automation system

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Abstract

This paper presents a novel building automation system that is decentralized and flat-structured. Each zone of the building is fitted with a smart node. It is a smart agent, which collects, handles and sends out information to its neighbours. All the smart nodes form a network that can realize self-organization and self-recognition. All kinds of control strategies can be converted into series of decentralized computing processes carried on by the smart nodes. The principle and mechanism of this decentralized, flat-structured building automation system are described in detail, and two use cases including evacuation in emergency and control of parallel-connected pumps based on this new system are further introduced.

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Keywords: intelligent building, smart building, decentralized, building automation, control system

1. Introduction

Smart building means more comfort, more safety and less energy consumption. This is usually achieved through the use of an automatic control system, controlling lighting, HVAC, elevators, power supply, safety and other mechanical systems in the building. However, although there are several iconic buildings, most smart buildings are not so smart. Many smart building systems operate manually (especially in China), while others that are automatically operated might have higher energy consumption, because of data drift or improper control strategies [1].

During the past approximately two to three decades, scholars have transplanted various kinds of popular technologies, from the industrial control fieldbus, to the Internet, to the smart building area [2]. BACnet, LonWorks, KNX and other fieldbuses or protocols have been developed to improve communication and data collection; OPC, SDN, SaaS and other software technologies have been transplanted in order to realize multi-subsystem integration; and thousands of articles have also been produced, introducing optimization strategies, in order to make occupants more comfortable and save more energy. However, many buildings with automation systems are still manually controlled or have high energy consumption.

Why can people be successful in the difficult area of industrial control, but struggle to make buildings smart? Previous efforts and results might indicate that building control might have its own special features, which have been ignored all along. First, a building is space oriented. Second, as tenants, zone division and zone function usually change every few months, buildings continually change. Third, building control is a multidisciplinary area. Experts or a multidisciplinary team are necessary, which means high cost. Finally, a smart building system should be low cost. When investing millions of dollars in an industrial control system, higher profits could be expected since the control system would increase

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production efficiency. A commercial building produces profit from rent, which has little relationship with smart building system. So building owners are not usually willing to pay too much for a smart system.

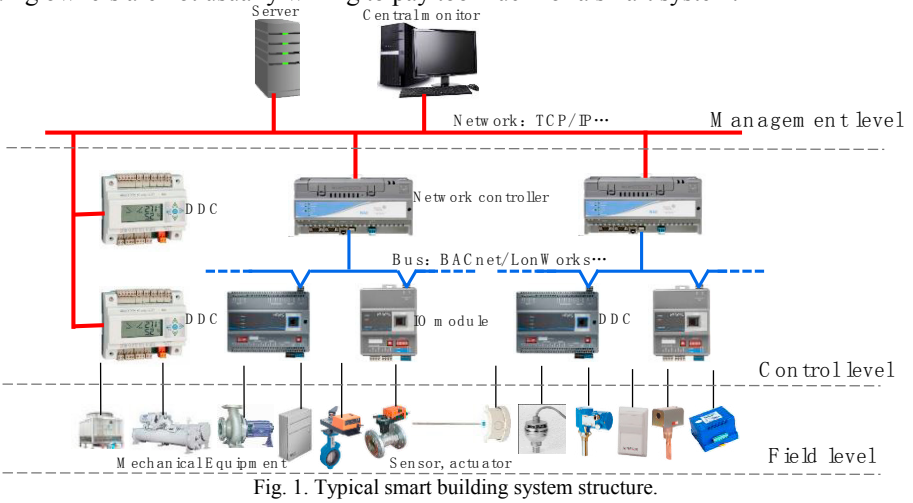

Fig. 1. Typical smart building system structure.

The technology used in smart buildings has continued to be upgraded as IT technology has improved, but the system structure has remained unchanged for almost 30 years [3]. Hence, very probably the structure is the key obstacle in a smart building system. It uses a hierarchical tree topology, as Figure 1 shows. Since this is quite different from building's space-oriented structure, 'configuration' has to be carried out. Configuration means redefinition of the building and its machinery systems via the central controller. In this process, virtual information needs to be bound and calibrated with physical sensors/controllers one by one. For a large-scale building of, for example, 50,000 m^2, nearly 10,000 pieces of information need to be bound. Configuration is boring, error-prone and expensive. Unfortunately, whenever a building changes, configuration has to be carried out.

We believe it's necessary to study building control specialties and redesign the system accordingly. The following sections present a new building model from different point of view. Based on new understanding, Section 3 introduces a decentralized, flat-structured system. Section 4 gives a brief introduction to two use cases based on the new system. Section 5 contains the summary, and it also presents a preliminary idea of a smart city application with the new system.

2. Model of building control system

Sensors, actuators and controllers are the basic components of today's smart building system. However, they are not the components of a building. From the building point of view, here the new basic units and their network are identified, and the physical process of building within the network of basic units is analyzed.

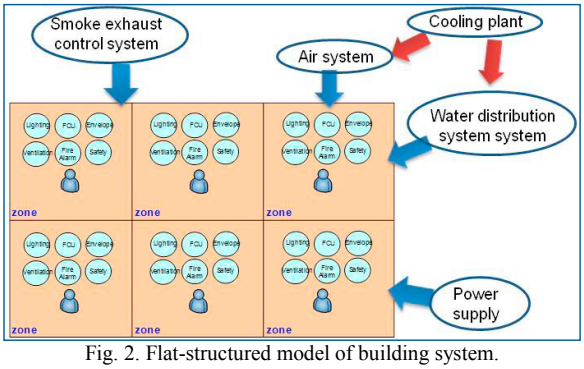

Fig. 2. Flat-structured model of building system.

2.1. Space-oriented and flat-structured

Outside the blocks network, there are some 'source' supply devices, such as chillers, pumps, fresh-air units, electricity power supply devices, etc. They do not serve the occupants directly, but produce heat, cold, power, and