EQUIPMENT SELECTION FACTORS OF INTEGRATED BUILDING MANAGEMENT SYSTEMS (IBMSS) IN SRI LANKA

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ABSTRACT

Management of facilities has become a complex task involving multitudes of disciplines. With increased awareness for efficient building operation, building owners and operators are looking for means to reduce the operational cost and to ensure the proper functionality of buildings and building services. To manage an organisation in an effective and cost-efficient way, these systems can be integrated into a single interface control solution called Integrated / Intelligent Building Management System (IBMS). Hence, in an intelligent building, IBMS acts as a complete information delivery system that monitors and controls a variety of mechanical and electrical systems and equipment such as such as lighting, Closed Circuit Television (CCTV), access control, fire detection, air conditioning, water management, elevator management, cark park management, etc. at an optimal level of efficiency. However, building systems and the equipment for the IBMSs should be carefully selected as those components have major contribution towards the overall performance of an IBMS. Hence, this research was carried out with the aim of investigating the factors that should be considered in selecting systems and equipment for IBMSs. A comprehensive literature survey, a preliminary survey and case study method was adopted to achieve the aim of the research. The required data were collected through semi structured interviews conducted among IBMS contractors of selected cases. The collected data were analysed, using code based content analysis. According to the findings, 'higher efficiency', 'cost, 'improved safety' and 'enhanced reliability' are the four major factors that should be considered in system and equipment selection. With the high demand and awareness of IBMS, it is fast becoming a part of facilities management and operational strategy in the organisations. Therefore, the careful consideration of above selection factors in designing would ensure the maximum performance of the IBMS.

Keywords: *Integrated Building Management System (IBMS); Sub Systems and Equipment; Present Status; IBMS Selection Factors; Sri Lanka.*

1. INTRODUCTION

Integrated Building Management System (IBMS) is a complete information delivery system that monitors and controls a variety of systems and equipment at an optimal level of efficiency. Ochoa and Capeluto (2007) stated that intelligent buildings are those that combine both active and passive intelligence, active features and passive design strategies, to provide maximum occupant comfort by using minimum energy. An IBMS typically consists of a personal computer-based graphic user interface, modular direct digital control (DDC) panels, DDC-based variable air volume (VAV) box controllers, microprocessor-based 'gateways' to interface integrate with other systems, and either a copper or a fibre optic communication network (Langston and Lauge, 2002). Panke (2002) introduced a brief list of events that should serve as a guide to the overall BMS project. According to author, these events are initial concept, information retrieval, design and system selection, field survey, candidate buildings, contract documents preparation, contract, installation and training, acceptance as well as operation and maintenance. Among them, the initial design and system selection plays a major role in assuring the overall performance of an IBMS. Therefore, several important factors should be carefully considered before selecting the systems and equipment for the

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IBMSs. However, literature on this area is limited and therefore an attempt was made in this research to fill the above gap by investigating the system and equipment selection factors of IBMS.

2. INTEGRATED BUILDING MANAGEMENT SYSTEM (IBMS): AN OVERVIEW

Over the past thirty years, the designers of Heating, Ventilation and Air Conditioning (HVAC) systems have gradually shifted towards the use of digital computers, replacing direct manual controls and simple analogue feedback loops such as thermostats (Langston and Lauge, 2002). This was the introductory stage of BMSs. Then the high technology concept of IBMS was introduced in the United States in the early 1980s (Coggan, 1996). The desire for an effective and supportive environment within which an organisation can reduce energy consumption, improve worker productivity, and promote maximum profitability for their own business has further stimulated the growth of highly adaptable responsive buildings integrated with IBMSs (Clements-Croome, 2001 cited Wong and Li, 2009).

IBMS denotes to a system where components communicate with each other and generally implies some form of central administrator, which permits monitoring and controlling of the building from a single point (CIBSE Guide H, 2000). Through the system integration, entire IBMS can be operated from a single head end personal computer, where the operating staffs has to learn about one set of operating software. Integrating the systems, with thorough understanding on the needs of the facility and the advanced planning process shall facilitate undisturbed conditions in the building and sustainable development through minimised energy consumption, first-class security and significantly lower life cycle costs. Further, intelligent buildings combine both active and passive intelligence to provide maximum occupant comfort (Ochoa and Capeluto, 2007). Proper BMS provide regulating output in response to varying indoor and outdoor conditions and also provide closer temperature and humidity limits in production areas for product quality. According to Colliers International (2007), building owners get benefited as IBMSs result in higher retention of tenants and rental returns due to less complaints and better comfort levels. Further, improved tenant relations are possible due to reduced complaints. Moreover, facilities managers can ensure more reliable plant operation and HVAC control from a central location. For the Service Contractors, the IBMSs allow remote service access for quicker response to its faults. It also permits more efficient diagnostics of plant faults and allows for historical performance data to be retained.

3. STRUCTURE AND FEATURES OF AN IBMS

The development of larger integrated systems depends on the existence of communication protocols which allow devices from different sources to communicate with each other. Therefore structure or system architecture of IBMS is based on the organisation of IBMS and the networks that monitor and control the entire building operation. CIBSE Guide (2000) has identified the entire communication procedure within the BMS in three different layers (Refer Figure 1). The sensors and actuators take place at the field level while intelligent controllers sit at the automation level. The head end supervisor has the access to all systems at field level. The management level accesses information from the automation level and has the access to a wide area network. Accordingly, it can exchange management information with independent systems within the same building or with other buildings. Though this structure has the advantage of organising network traffic efficiently, it requires the additional complication of linking the three levels. Therefore a single network model is sufficient for many applications.

According to Panke (2002), there are five basic hardware components that are used in IBMSs such as sensors, actuators, microprocessor-based field panels (controllers), communication links, and a central operator station. Sensors transmit information that defines a single operating condition, such as temperature or pressure. This information is supplied to the field panels (controllers) for monitoring or decision-making purposes. Actuators are the mechanical interfaces that implement actions initiated by the field panels in accordance with the inputs received. Information relating to the entire process has transmitted over the communication links to a central operator station. The next important section of an IBMS is the network that connects several devices together and communicates within the system. Physical medium and protocols are the main two parts of a BMS network. Protocol is a language that rules the entire communicating signals through the physical medium. Different transmission systems and media use alternate physical mediums including twisted pairs, voice grade telephone lines, coaxial cables, electrical power lines, radio frequency, and fibre optics for communications between the field panels and central operator station.

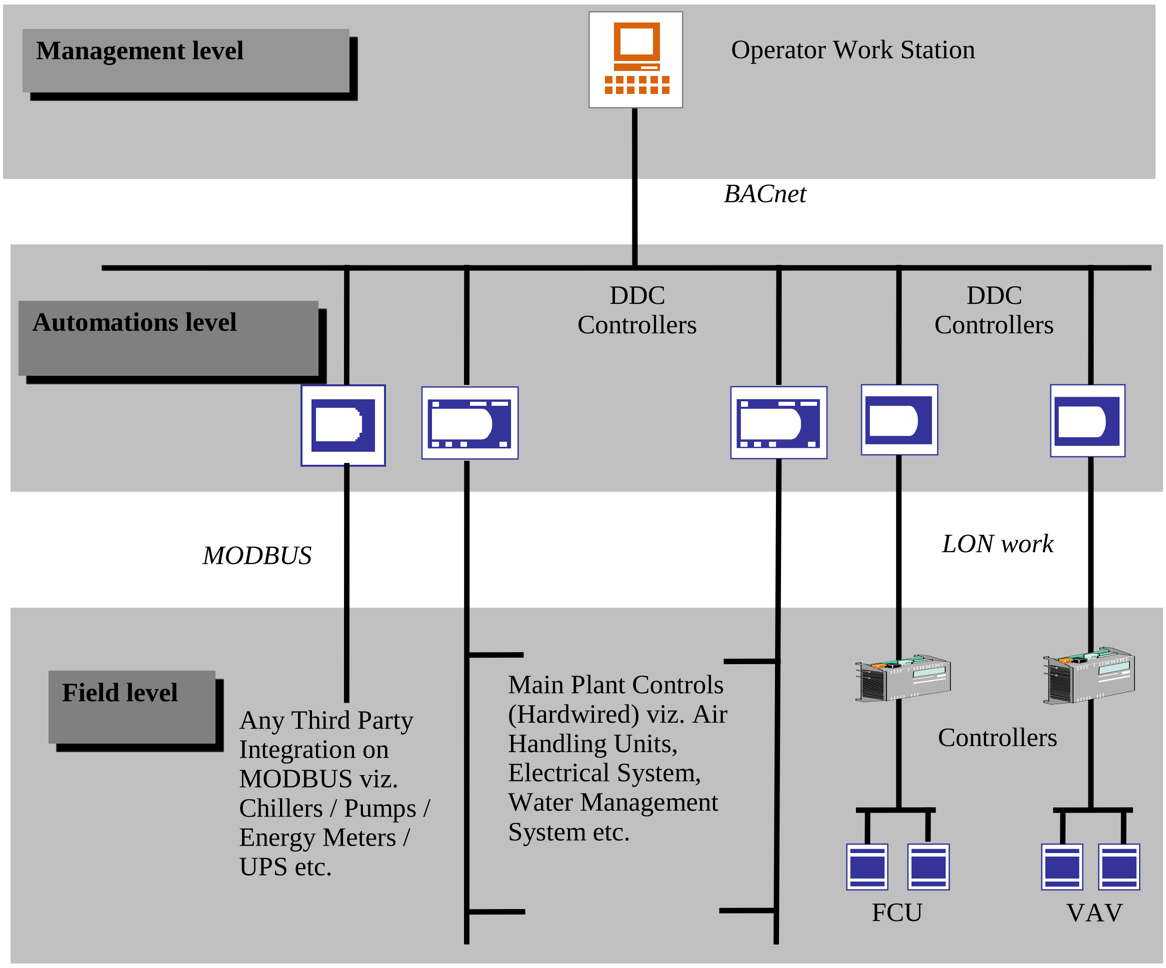

Figure 1: Typical Structure of an IBMS
Source: Seimens (2008)

According to Siemens (2003), IBMSs are open to operation as open system architecture is widely supported, making it possible to integrate third-party systems at all three levels of the system. Further, a well-designed IBMS provides clear user guidance and graphic-based display to take account of ergonomic principles. Innovative web technology is used both at the automation level and the management level. Through these web accesses, fault messages can be received and acknowledged with cost-efficient standard equipment such as Web-Pad, PC or mobile phone. Then system can be kept up to date all times irrespective of the location. As Siemens (2003) pointed out, due to technological advances and improved project handling, costs per data point are falling steadily and therefore, IBMS is economical in every phase. When concerning about the life cycle cost of the plant, economy-minded building operator focus on the sensible start-up costs, efficient and cost-effective support during operation plus flexible service options.

4. SUBSYSTEMS AND EQUIPMENT SELECTION FACTORS OF AN IBMS

A well-planned control system offers improved management of building services and can form the core of an integrated facilities management system, covering other building-related services (Jankovic, 1993). Mostly, intelligent building control products are designed to provide environmental control, mobility, communications facilities, fire protection and security in the building (Wong and Li, 2009). However, Figure 2 shows various equipment and sub systems that can be integrated with IBMSs.

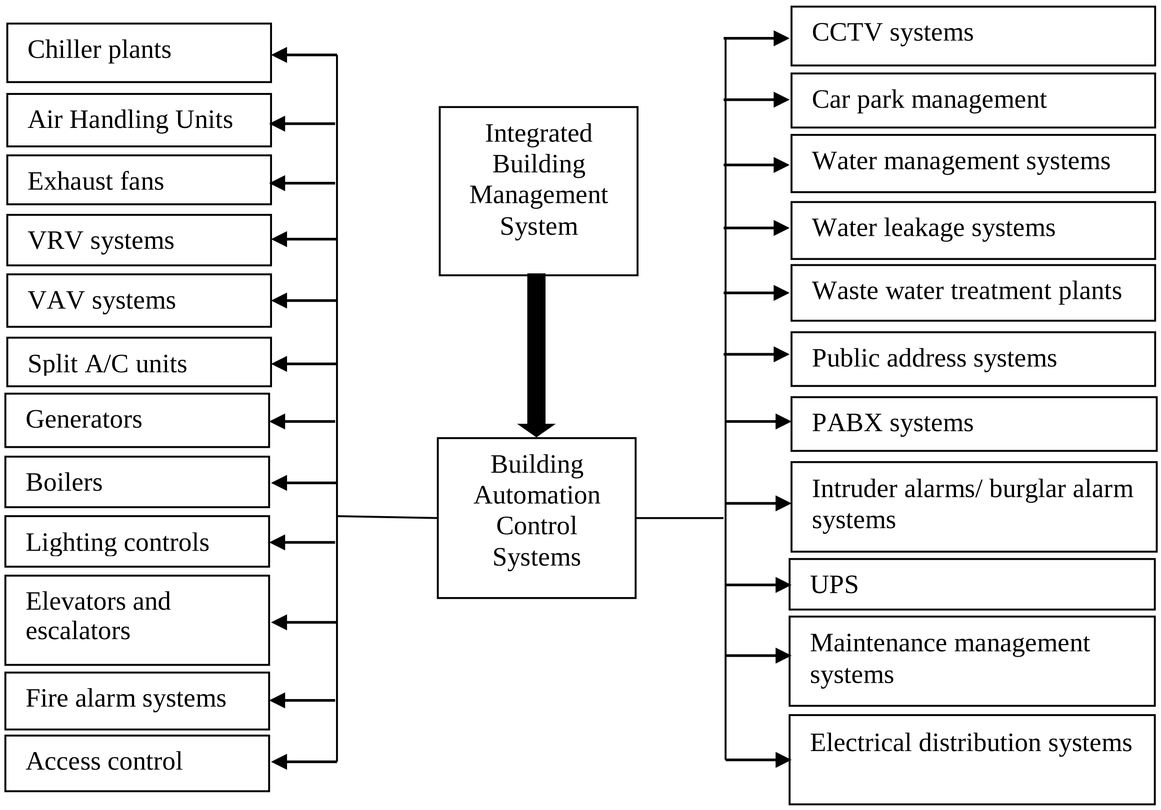

Figure 2: Sub Systems that can be Integrated to IBMS

The aim of building intelligence is to help enterprises, facilities managers and occupants alike realise goals cantered on cost, comfort, convenience, safety, long-term flexibility and marketability. Therefore, intelligent buildings should be sustainable, healthy and technologically strong, meet the needs of occupants and business and should be flexible and adaptable to deal with changes. In order to cater these needs, the building systems and the equipment should be carefully selected and integrated with the IBMS. Therefore, having proper knowledge on the factors that should be considered in selecting those will enable the facilities managers to successfully design and install an IBMS. According to CIBSE Guide (2000), selection of the suitable physical medium should be based on the initial cost, efficiency (Scan rate), reliability, maintainability, expandability, and compatibility with future expansions. As stated by Wong and Li (2006), work efficiency was perceived as the most important core criterion for the selection of IBMSs. Further, service life and operating and maintenance costs were regarded as the two most crucial sub-criteria in various IBMS systems. According to the researcher, long-term expenses are also of major concern of many owners and decision makers. Moreover, researcher pointed out a strong need for the consideration of providing a comfortable and productive working environment to satisfy the physiological needs of the occupants in buildings.

5. RESEARCH METHODOLOGY

A three step approach, i.e. a comprehensive literature review, preliminary survey and case studies were employed in achieving the aim of the research. First, the system components, protocols, hardware, sub systems and equipment, benefits and other fundamental information of IBMS were identified through the literature review. The main objective of the preliminary survey was to get opinions of experts to inspect and study about IBMS prior to the interviews. Furthermore, it was aimed to gather expert opinions to identify and list out selection factors of sub systems and equipment. The preliminary survey was conducted by interviews within five IBMS experts in the industry gathered their opinions to develop interview guideline for the detailed study. This study is an exploratory type research and therefore, case study approach was selected to achieve the aim of the research. The unit of analysis or the case in this research was contractor organisations who design, supply, installation, testing and commissioning IBMSs in Sri Lanka. Three contracting organisations, which have completed lots of IBMS projects and who have more than five years of experience in the field of IBMS were selected in order to verify the list of equipment and system selection factors identified after the expert survey. After developing interview transcripts, semi structured interviews were conducted for the data collection. Code-based content analysis was used for the analysis.

6. RESEARCH FINDINGS

After identifying the systems and sub systems which are integrated with IBMS, a list of selection factors were identified based on the literature findings. Then some changes in the list of sub systems and equipment were also done based on preliminary survey findings. Variable Air Volume (VAV) System, car park management system, water leakage detection system, waste water treatment plant, intruder alarm/ burglar alarm and maintenance management system were introduced newly as sub systems and equipment. The list of selection factors was finalised with the experts' opinions. Several new factors were newly added to the list while some factors were removed and some were combined where it was needed. Some new questions were added to the interview guideline regarding the tendering process and service and maintenance of the system while some questions were removed and adjusted based on experts' views.

The case studies were conducted among three organisations which have more than five years of experience in the fields of IBMS. In selected three cases, i.e. Cases A, B and C, the resource persons who involve in IBMS projects were project managers, project engineers, design engineers, commissioning engineers, technical executive and technicians. When discovering the demand for IBMSs in Sri Lanka, it shows that there is a huge demand in office buildings compared to banks, hotels and hospital buildings. This demand can be seen in both private and public sectors. As interviews revealed, there are lots of advantages of IBMS for building occupants. Basically IBMS optimise energy consumption. On the other side it maintains comfort level and increase efficiency in the building. And also, having IBMS building owners can reduce labour cost and ensure efficiency operation of sub systems and equipment.

This exploratory study evaluated and identified the major factors that should be considered in selecting sub systems and equipment for an IBMS. The findings have been presented in Table 1. Each sub system and equipment has a number of selection factors when deciding to integrate them to an IBMS. All the contractors are thoroughly concern about these selection factors when they design the IBMS. However, the selection factors identified through the research could be categorised into four main selection factors as higher efficiency, cost, improved safety and enhanced reliability. Among them, higher efficiency is perceived as the most important factor. Further, economical maintenance, improved safety and enhanced reliability are also considered significant.

In ensuring the overall efficiency of the IBMS, the work efficiency of each and every component is important. Further, the IBMS operator should be able to control and monitor sub systems and equipment during the operation and therefore, controlling and monitoring features are also considered when designing an IBMS. By measuring the working hours of sub systems and equipment building owners are comfortable to prepare maintenance schedules. Time scheduling feature assist in improving energy saving. Energy saving is a one of benefits of IBMS and therefore selected sub systems and equipment should optimise the energy consumption. Therefore, energy efficiency is also a factor which is considered in selecting systems and subsystems for the IBMS.

Sub systems and equipment can also be integrated with other systems to further optimise building comfort, safety and efficiency. For an example, pumps integrate with chillers, fire alarms integrate with AHUs and lifts, cooling towers integrate with chillers etc. Therefore, the ability of the sub systems and equipment to be integrated with others is also an important consideration. In a case of changing present status or an emergency the IBMS should be capable of make alarms and get immediate response. Moreover, for a building public announcement are very essential, especially in an emergency. And also current position of systems should be indicating in the IBMS. Further upgrade is important to all sub systems and equipment for the better operation of the building. Therefore, immediate response, indicate alarms public announcement, current position and further upgrade are also selection factors of sub systems and equipment. Initial cost and operating and maintenance costs are regarded as the two most crucial selection factors in selection of sub systems and equipment.

Table 1: System and Equipment Selection Factors of IBMS

System/ Equipment	Selection Factor																												
	Higher Efficiency	Work efficiency	Controllability	Monitoring ability	Preventive maintenance scheme	Time Scheduling feature	Energy efficiency	Interconnect with other sub systems	Response time	Indicate alarms	Public announcement	Possibility for further purgation	Indication of current position	**Cost**	Initial costs	Operating and maintenance costs	**Improved Safety**	Water leakage detection	Fire detection and fighting	Provision of safety and security	**Enhanced Reliability**	Productivity	Occupancy comfort	Indoor air quality	Control light level	Control temperature	Fuel consumption	Water consumption	Area under power supply
Chiller Plant		●	●	●	●	●	●	●	●	●		●			●	●						●	●			●			
Air Handling Unit		●	●	●	●	●	●	●	●	●		●			●	●						●	●	●		●			
Exhaust Fans		●	●	●		●			●	●		●			●	●							●	●					
Cooling Towers		●	●	●		●	●	●	●	●		●			●	●						●	●			●			
Pumps		●	●	●		●	●	●	●	●		●			●	●													
VRV System		●	●	●	●	●	●		●	●		●			●	●						●	●	●		●			
Fan Coil Unit		●	●	●	●	●	●	●	●	●		●			●	●						●	●	●		●			
VAV System		●	●	●	●	●	●		●	●		●			●	●						●	●	●		●			
Split Unit		●	●	●	●	●	●					●			●	●						●	●	●		●			
Generators		●		●	●	●		●		●		●			●	●						●	●				●		
Boiler		●		●	●	●				●		●			●	●				●							●		
Lighting		●	●	●		●	●					●			●	●						●	●		●				
Lifts and Escalators		●		●				●		●		●	●		●	●				●			●						
Fire Alarm				●				●	●	●	●	●			●	●			●	●									
Access Control		●		●						●		●			●	●				●			●						

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	Higher Efficiency	Work efficiency	Controllability	Monitoring ability	Preventive maintenance scheme	Time Scheduling feature	Energy efficiency	Interconnect with other sub systems	Response time	Indicate alarms	Public announcement	Possibility for further purgation	Indication of current position	**Cost**	Initial costs	Operating and maintenance costs	**Improved Safety**	Water leakage detection	Fire detection and fighting	Provision of safety and security	**Enhanced Reliability**	Productivity	Occupancy comfort	Indoor air quality	Control light level	Control temperature	Fuel consumption	Water consumption	Area under power supply
CCTV				●								●			●	●				●									
Car Park Management				●						●		●			●	●				●									
Water Management System		●		●						●		●			●	●		●					●					●	
Water Leakage Detection System				●						●		●			●	●		●		●									
Waste Water Treatment Plant		●		●						●		●			●	●												●	
Public Address System											●	●			●	●													
PABX System		●		●								●			●	●													
Intruder Alarms/ Burglar Alarm				●						●		●			●	●													
UPS		●		●		●				●		●			●	●				●									
Maintenance Management System		●		●				●		●		●			●	●						●	●						
Electrical Distribution System		●		●		●		●	●	●		●			●	●				●									●

When it comes to cost factor, initial cost and long-term expenses are the major concern of many building owners and decision makers. Selected sub systems and equipment of an IBMS such as leak detection and fire alarm systems provide safety and security for building owners and occupants. Therefore, security features are also considered in selecting components of IBMS. The high rank of occupancy comfort in sub systems and equipment implied a strong need for the provision of a comfortable and productive working environment to occupants. Selecting some sub systems and equipment for integration, it increases productivity and indoor air quality. Controlling of lighting level and temperature are other factors for selection of IBMS. Fuel consumption and water consumption is essential factors to consider when selection of sub systems and equipment.

7. CONCLUSIONS

A modern building contains various technical services in addition to HVAC, such as lighting, lift control, security and access control, CCTV, as well as the information technology network necessary for the user's business operation. Therefore, the management of facilities has become a complex task involving multitudes of disciplines. The role of the facilities manager is to provide a responsive and supportive environment in order to achieve the business success. A cost effective facilities management becomes possible when IBMSs are properly operated. The IBMS refers to a system where components may communicate with each other and generally implies some form of central supervisor, which permits monitoring and control of the building from a single point. When properly integrated in to a facility, IBMS can effectively optimise energy consumption, monitor and control of comfort conditions, enhance environmental quality, provide critical alarms and remedial actions, monitor performance and safety of assets and provide security solutions. Though IBMS is a relatively new concept for Sri Lankan industry, an increased application of IBMS could be seen in recent years and nowadays in Sri Lanka some of organisations provide more intelligent approach to the facility management, safety and energy control in IBMS. Therefore the knowledge on selection, design operational and maintenance aspects of IBMS is essential to a facilities manager. This research basically addressed the selection factors of the systems and equipment which are integrated with an IBMS. According to the research findings, various factors are considered when selecting sub systems and equipment to integrate with the IBMS. They can be categorised into four major selection factors as 'higher efficiency', 'cost', 'improved safety' and 'enhanced reliability'. Among them, efficiency is the as most significant important factor that should be given careful attention. The mangers of facilities should gain a comprehensive knowledge on the tools and techniques and well as criteria that should be taken into account in considering above selection factors and making the appropriate selection decisions.

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