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Survey on Multipoint Measurement Technology Using Optical Fiber

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Abstract— Energy consumption in data centers is increasing dramatically as the information technology infrastructure provides higher speeds and capacities and the deployment of it equipment expands. In a data centers , the percentage of energy consumed by air conditioning is high at about 40%, and reducing this energy use has become major issue against the background of global warming . To make detailed temperature measurements with the aim of achieving energy-efficient data centers, The multipoint temperature measuring technology to increase the spatial resolution by more than twice that of existing technology .This uses a new algorithm for correcting signal processing output from temperature-distribution measuring equipment that utilizes Raman –scattering light in on optical fiber . I am also presenting technology for fast and reliable laying of optical fiber on server racks .These technologies enable accurate and detailed measurement of temperature distribution in data centers, which should in turn lead to optical air conditioning and an energy –saving effect.
Keywords— IT,DTS,OFC,ITU

I. INTRODUCTION

In today's world information technology is widely used. It has been noticeably in recent years due to the vast infrastructure of Internet and the increase in the number of servers of high performance and other computer. This system has dramatic jump in the data centers for better telecommunication system .for number of server in data centers required a better environment in the room. It required more power in industry so far consumption of power in IT society is more. In data centers the amount of power consumed in 2006 is about 1% of the total amount of power in the world but if we take current trends continue below figure is expected to increase markedly by 5 to 9 times by 2030 .from all these reasons for making data center more energy efficient has become environmental issue against the backdrop of global warming and the need to preserve energy resources.

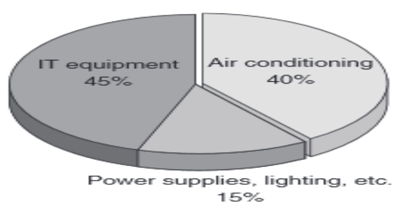

Fig.1 Breakdown of Energy Consumption In Data Centers

In a data center contains a many servers generally from few tens to thousand and their working servers generate a considerable amount of heat. If the result large scale air conditioning equipment has become essential for cooling the environment in data centers or servers and keeping the room temperature below specified value .The power required for air conditioning has risen to about 40% of the total power consumed by data centers . Consequently reducing energy used by air conditioning in data centers has become essential in order to achieve energy efficient data centers.

II. LITERATURE SURVEY

Now a days different techniques used for temperature measurement .it is now over 40 years since the thought that optical fiber could be useful approach to sensing and measurement first emerged in 1975.STOLEN and IPPEN demonstrated Raman scattering in optical fiber. However, throughout 1975's and half part of the 1980's .Raman scattering remained primarily laboratory curiosities .distributed temperature sensors measure temperature by means of optical fibers .In 1980's with significant improvements in the technology and application scenario over the last decades.

Before this process different sensors are used traditionally like thermocouples, thermistor and platinum resistance thermometer bulbs. More recently integrated circuit type temperature sensors ,which integrate circuit type temperature sensors with communication functions in a one chip configuration, have become practical and have been applied practical and have been applied .However, conventional temperature sensors such as these cannot easily handle a few hundred to several thousand servers considering the work involved in laying signal-lines, the need to shorten measurement time, the cost involved, and other factors. Accordingly, to achieve a temperature measurement technique that can handle such a large array of servers.

This technique is using for temperature measurement can detect fires in automobiles or subway trends check for abnormal temperature in power lines or chemical plants and measure temperature distribution within boreholes in oil well drilling or geological surveys etc. For these application spatial resolution along the length of the optical fibers is adequate but not really suitable for efficient measurement of temperature distribution in a data center which is extremely complicated .from above all reasons we conducted a comprehensive development program to improve the systems spatial resolution to enable optical fiber based temperature sensing which is applied in data center.

III. TEMPERATURE SENSING USING OPTICAL FIBER OVERVIEW

In today's world optical fiber is indispensible for achieving high speed large capacity communication system .whenever laser light with wavelength in the near infrared region is entered into optical fiber, various types of scattered light are produced as a result of the physical state of the fiber's silica glass. There are three main types of scattering techniques to occur here. Rayleigh scattering at the original wavelength , Briliuouin scattering at a wavelength shifted by about 20 nm and Raman scattering at a wavelength shifted by about to 50 nm.

A. Comparison of scattering techniques

Scattering	Rayleigh	Raman	Brillouin
Temp sensitivity (% / ^{0}c)	0.54	0.8	0.01
Temperature range (^{0}c)	5 to 10	0 to 70	-30 to 60
Accuracy (^{0}c)	1	10	1
Spatial resolution (m)	1	3	3-5
Fiber length range(m)	170	1000	51000
Measurement time(s)	2.5	40	4
Strain(um)	_	_	100

The thermal effects along the fiber cause lattice oscillations .Raman scattering is the light falls on the thermally excited molecular oscillations, the photons of the particles and the electrons of molecule undergo a interaction resulting in a scattered light .

The backscattered light required three component to measure the temperature i.e. The Rayleigh scattering, the wavelength of laser source ,the stokes component with the higher wavelength in which photons are generated and the Antistokes component with a lower wavelength . The intensity of the antistokes band is temperature dependent & stokes band is temperature insensitive ,so the ratio of the antistokes light & stokes light gives the local temperature measurement .This was developed in 1980 at Southampton university U.K.

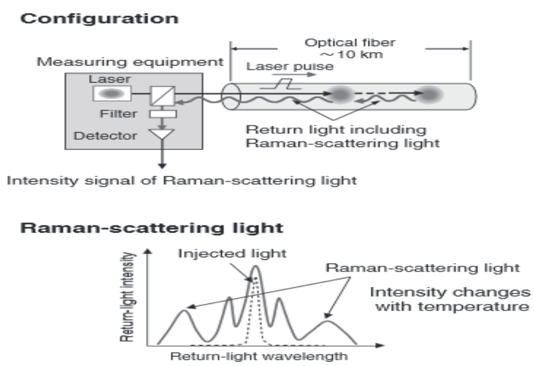

Fig-2. Principle of Optical Fiber Based Temperature Measurement

In the detail scenario , laser light in the form of short pulses injected into optical fiber with a duration of several nanoseconds then while the light propagates through the optical fiber. The produced backscatter intensity of Raman scattering light generated at various locations in the optical fiber is measured together with delay propagation time .the principle is shown in above figure .according to time the change in intensity correspond to temperature at different locations in the fiber and the distance of that location is found by multiplying the delay propagation time of Raman light by the speed of light propagation in optical fiber.(about $2*10^8$ m/s)

Example for temperature measurement with respect to time

In a 10 km long optical fiber ,excitation time is about 50 us to arrive at the other end that means temperature information along the whole 10 km of the optical fiber can be obtained within about 100 us .as already known typical silica based optical fiber is used for communications purpose gives excellent heat resistance ,which is usually makes it possible to measure even high temperatures above 200^0c this can be somewhat depend on the type of protective sheath used for optical fiber . This technique is mostly used 1gb/s class multimode optical fiber it is reasonably cost effective.

If we consider table 1 shows comparative summary of the different temperature sensing system developed in time i.e. Rayleigh ,Raman & Brillouin scattering with considerations even though the Rayleigh scattering shows best occurrence. It is only limited in terms of range of fiber length which is more important these days to monitor longer length of cables from other point of view brillouin scattering is best for provide best length range with highest temperature sensitivity and relatively good measurement time Brillouin scattering Could also detect the distributed strain which can not be done by other methods but at one time the measurement of the distributed temperature and strain can not be done simultaneously i.e. Application of the Brillouin scattering would likely be preferred choice is future developments.

IV. USE OF TEMPERATURE MEASURING TECHNOLOGY IN DATA CENTERES

Since short wavelength pulses of excitation light is transmitting through optical fiber is about 2m to determine the temperature over shorter distance is difficult .they tried to increase the spatial resolution by giving the different profiles to optical fiber to check the output temperature responses.

A. Spatial correction technique

The measuring system feeds Raman-scattering light from pulses of excitation light into a optical detector inside the measuring equipment and calculates the fiber temperature by integrating that signal. While in some circumstances , if heat is not uniformly distributed along the cable corresponding to the excitation of light pulse width, accurate temperature measurement cannot be performed. The “minimum heating length “is the length of optical fiber needed to make accurate temperature measurements . When part of the optical fiber is heated uniformly , the temperature distribution measured in the lengthwise direction is a curve having a smooth convex shape like a normal distribution . The heating section is shorter than the minimum heating length then it produces a measurement error ,so by giving a optical fiber a different step shape temperature over length shorter than the minimum heating length and make accurate measurement which derives a transfer function for the optical fiber’s temperature distribution. It will slightly differs according to the type of optical fiber, used in measurements has been determined, the original temperature profile can be reproduced by using it to de convolute the obtained temperature-distribution data.

V. TEMPERATURE MEASURING POINT

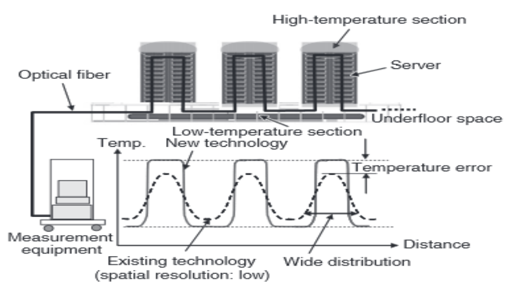

Fig3-Schematic Diagram of Signal Correction

Forced-air system of cooling is used by many data centers in which chilled air is blown upwards from the free-access floor i.e.

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Space underneath a raised floor . While taking this in mind, they installed a section of optical fiber at a location similar to the bottom section of a server rack that had a stable low temperature reading here, the temperature measurement technique is used as a reference temperature enabling the complex temperature distribution within the server rack to be measured. For this purpose, an algorithm is developed that can reproduce temperature-variation data with high accuracy. In this algorithm, That algorithm set up a high-order polynomial that corresponds to the temperature change envisioned within the server rack and approximately solve multidimensional partial differential equations using the temperature transfer function and temperature information from the reference-temperature point. A schematic diagram of signal correction for increasing accuracy in conjunction with the spatial correction technique described in section is shown in Figure 4.1.1. This signal-correction algorithm can follow changes in temperature for optical fiber lengths shorter than 1 m, thereby enabling optical fiber to be used at more than twice the efficiency of existing technology. Although there is a tradeoff between temperature accuracy and the number of integrations, accuracy of ±0.5°C after 30 s of integration can currently be achieved. This level of response and accuracy is sufficient for monitoring and controlling an air conditioning system.

VI. OPTIMIZATION OF OPTICAL FIBER

As mentioned earlier, relatively cheap graded-index multimode optical fiber can be used for this measurement technology. However, there are slight limitations on the type of outer covering. The data-communications optical fiber often seen in typical data centers and offices, called optical fiber cord or optical fiber cable, is covered with reinforcing material made of are amid fiber or with a thick sheath to provide greater mechanical strength. This covering, however, increases the time taken for heat to propagate to the core of the optical fiber and hence lengthens the temporal response. In short, the speed of heat transmission in optical fiber depends greatly on the thickness of the optical fiber. They performed thermofluid simulations to determine the optimal optical fiber thickness. It found that an optical fiber with a diameter of less than 1mm would be needed to achieve a 10-s temporal response for a 10°C step response. Here, an optical fiber core (0.9mmφ) or an optical fiber strand (0.25mφ) would be suitable. For this optical fiber, materials like nylon, ultraviolet-curable resin, or polyester elastomer could be used for the outer covering. These all have different dynamic properties such as elasticity and flexibility.

VII.APPLICATION

A. In civil engineering, health monitoring of dams and dikes is very important to identify early any leakage in order to prevent catastrophic failures like flooding, etc. The principle relies on the fact that due to leakage, significant water flow causes temperature change between the canal water and the ground. The different temperature sensing system then effectively provides the distributed temperature profile along the dam. However, the change in temperature could also be caused by other factors like seasonal variation, precipitations, etc.

B. This systems are also applied in the oil and gas industry. In oil/gas well, DTS installations are typically categorized as retrievable, semi-permanent, and permanent. DTS is used to monitor the temperature log of the well. The temperature log could then be associated with the effects of the liquid flow when a well is shut in. Gas entry into a channel causes a cooling effect which can be detected in the static rathole . The DTS temperature log could also provide information on the cooling effect in a water injection well.

C. Distributed temperature sensing systems are also used to monitor wells on a pad or production platform, steam breakthrough in a production well.

D. Automatic fire detection is an important topic to prevent asset damage and human casualty. Automatic fire detection system are based on optical smoke detector, ionization detector, infrared or ultraviolet flame detection, etc.

E. For safe electrical operation, in mines, shuttle car trailing cables should be operated below the safety limit which is about 90^0 C.

VIII. CONCLUSIONS

With the aim of reducing the energy used by air conditioning systems in data centers , they developed a multipoint temperature measurement technology using optical fiber that enables accurate and detailed temperature visualization. Looking forward, plan to use this temperature measurement technique as a basis for developing a dynamic air conditioning control technique that can automatically optimize the operation of an air conditioning system

IX. ACKNOWLEDGMENT

The cost of systems and installations vary greatly for different applications and settings. For example, in the power systems and

cable applications often the voltage level, type of cable, distance, etc. Are the influencing factors. Typical costs could be in the range of USD 100 000. In oil and gas applications, also the cost depends highly on the well configurations, distance, applications, etc., typically being in the range of USD 50 000–150 000 . Therefore, the cost of the DTS systems is still on the higher side. Therefore, one obvious future need would be to have cost-effective DTS solutions maybe in the range of USD 10 000–20 000, or less. Despite the relatively higher cost, the real-value of systems is to provide distributed temperature and/or strain measurement. This is often useful for safety critical or difficult to access applications, involving equipments which themselves are highly expensive, Getting a direct and continuous measurement of the temperature profileto prevent potential damage to such equipments is a growing trend in continuous condition monitoring for predictive maintenance. Therefore, a better way of judging the value of DTS-based monitoring would be to introduce alternative business models based on total cost of ownership for expensive devices. The growing relevance of wireless communications has been driving research and development to enable cost-efficient support of very high data rates to be delivered to a large number of users . The high bandwidth targets for future networks are well reflected in the ITU's call for IMT-Advanced .As interference poses the main limitation in today's networks ,cooperative signal processing is seen as a key enable to achieve these targets .However ,cooperation among base station in traditional cellular infrastructure is problematic because interconnections are often very limited in capacity and investigations on more flexible and cost-efficient future architectures are in progress .A promising concept was proposed in the European research project FUTON . Itis based on the use of Radio over fiber technology to create a distributed antenna system that is capable of supporting the high requirements of future wireless networks

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