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## Implementing Self-managed Ethernet Networks with IQ1000 Smart Switches, Discussion Document

This paper details improved ways to build resilient IP-based Ethernet networks for critical applications such as Video Surveillance, Security and Building Automation. In order to achieve significant network performance improvements a new class of Ethernet Switch is introduced: the Self-Managed Ethernet Switch. Two key areas are explored:

- 1) New ways to deploy and manage Ethernet switches
- 2) How to build high performance Ethernet Rings with fast failure recovery times.

Ease of Use Factors in IP Networks.....	2
A New Class of Ethernet Switch -Self-Managed .....	2
Why Is a Self-Managed Ethernet Switch so Useful? .....	3
True Plug and Go Installation and Operation .....	3
IQ Rings- Both Fibre and Copper.....	4
Spanning Tree Protocol -Designed for Trees not Rings.....	4
Electing a root brldge .....	5
Brdge ProtocolDataUnlts (BPDUs).....	5
Managed Swltch STP swltch port states .....	5
"Enhanced" Versions of STP -RSTP and MSTP.....	6
What Happens When Spanning Tree Protocol Is "Wound Too Tight" .....	6
Hop Limitations of STP vs. Intelligent Quasar Technology .....	6
Change/ Moves/ Adds on STPvs. IQ Ring.....	6
Drawbacks of using Spanning Tree Protocol for Ring Topologies.....	7
IQ1000 Self-Managed Switches are designed for Ethernet Rings .....	7
Self-Managed IQ1000 vs. STP-based Managed Ethernet Switch Highlights .....	8
IQ Rings Provide "Armoured" Data Paths .....	9
Be Wary of Mis-leading Ring Recovery Time Advertisements .....	9
Self-Managed Switches have Superior Return on Investment .....	10
Summary - Compare Technologies and Choose Carefully .....	10

04/05/2007

1

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## Ease of Use Factors in IP Networks

When creating Ethernet networks for IP-based devices such as IP Video cameras, sensors, control points and access devices, there are several factors that need to be taken into account:

- Ease of Installation and Provisioning
- Ease of Network Management
- Ease of Network Maintenance · Level of Network Resiliency
- Level of Security
- Data Traffic Throughput Management

These issues are addressed by answering the following types of questions:

1. How can IP networks be created quickly and easily and minimize the demands on IT resources?
2. Creating a Gigabit Ethernet network that is resilient and self-heals faster than legacy Ethernet networks in the event of network difficulties?
3. How can IP streams from devices such as IP Video cameras be secured?
4. Creating a hacker proof network for critical devices and data?

As will be discussed in order to address the ease-of-use networking factors and answer these questions, a Self-Managed Ethernet Switch should be deployed.

## A New Class of Ethernet Switch -Self-Managed

The first class of Ethernet switches introduced to the market were Unmanaged. It was easy to connect Ethernet devices like PC's, to this type of switch. But Unmanaged Ethernet switches do not have any native intelligence or ability to be externally managed in any way. In order to correct the shortcomings of the unmanaged switches, Managed Switches were introduced that had communications capabilities, support for new networking protocols, and

04/05/2007

2



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the ability to have many types of parameters set by the Network Administrator. As more and more features have been added over the years Managed Ethernet switches have become complex to administer and demand a high level of operator expertise.

What if the ease of installation and use of the Unmanaged Switch could be combined with the power of the Managed Switch to receive the benefits of both? This is exactly the question answered with the introduction of the IQ1000 series of Self-Managed Ethernet Switches.

## **Why Is a Self-Managed Ethernet Switch so Useful?**

Self-managed switches have integrated intelligence and therefore do not need to be administered. Self-managed switches do not need protocols such as SNMP for administration. As a Self-Managed switch, the IQ1000 has auto discovery capabilities when IP devices are plugged into the Ethernet service ports. Since all data from all the Ethernet service ports is circulated around the Gigabit Ethernet ring, applications can access the appropriate data streams from any port as necessary. Since IQ1000 switches do not need to be administered they do not have IP addresses. The equipment connected to an IQ1000 such as IP Video Cameras, Routers, PC's and Computer Servers do have IP addresses. The IQ1000 automatically establishes connectivity to each device and is essentially a transparent Ethernet fabric.

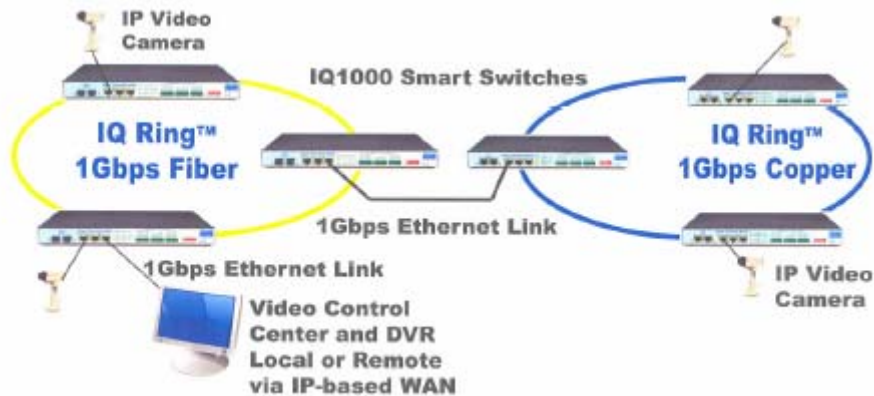
## **True Plug and Go Installation and Operation**

Self-Managed Ethernet switches provide extraordinarily easy installation and operation. As shown in the figure below, the IQ1000 switches are connected and powered on. The IQ1000 automatically creates a self-healing IQ Ring. The IP devices such as cameras, computer servers and other Ethernet switch/routers are then connected to the 10/100/1000Mbps Ethernet ports. When these IP devices are attached to the ring, inter-device communication transactions begin the same as any IP Ethernet network.



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## **IQ Rings- Both Fibre and Copper**

As shown in the diagram above, the IQ1000 which has fibre Ethernet ring ports, and IQ1000C which has copper Ethernet ring ports, function identically. The introduction of the IQ1000C brings the IQ Ring capabilities to the Cat5e/ Cat 6 copper wiring. This provides a powerful networking choice when distances between switches is less than 100 meters.

All the IQ Smart Switches work ubiquitously across all the platforms. This provides unrivalled deployment flexibility for various network configurations and topologies.

## **Spanning Tree Protocol -Designed for Trees not Rings**

In order to appreciate the power of a Self-Managed Switch Ring, it is instructive to understand how Managed Switches handle networking in a ring topology using Spanning Tree Protocol.

The Spanning Tree Protocol, which is also referred to as STP, is defined in the IEEE Standard 802.1D. As the name suggests it finds a spanning tree within the mesh network formed by the installer, whether purposefully created or not, and disables the links not part of that tree. STP is used in switched networks to prevent loops. (Note, when building Ethernet Rings we are trying to do the opposite and build loops!)

IT Administrators who are using Managed Ethernet Switches with STP to build ring topologies must go through many steps and be very careful how these steps are implemented. In order for Managed Switches to create a Spanning Tree, the following steps must be taken:

- Elect a root bridge.
- Find paths to root bridge.
- Determine least cost (measured as sum of all traversed port costs) path to root bridge.
- Disable all other root paths.



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## ***Electing a root bridge***

Each Managed Switch has a unique identifier (ID) and a configurable priority number; both of these numbers make up the Bridge Identification or BID. The BID is used to elect a root bridge based upon the lowest priority number; if this is a tie then the numerically lowest ID wins. Other switches in the network that use spanning tree will use the same algorithmic process to calculate the shortest path to the root bridge and so produce a loop free tree topology where multiple paths to the root bridge exist.

## ***Bridge ProtocolDataUnits (BPDUs)***

BIDs and other Spanning Tree Protocol information are carried in special data frames called Bridge Protocol Data Units (BPDUs). BPDUs are exchanged regularly (every 2 seconds by default) and enable switches to keep track of network changes and activate or disable ports as required. When a device is first attached to a switch port, it will **not** immediately start to forward data. It will instead go through a number of states while it processes BPDUs and determines the topology of the network. When a host is attached such as a computer, printer or server, the port will always go into the forwarding state, albeit after a delay of about 30 seconds while it goes through the listening and learning states (see below). The time spent in the listening and learning state is determined by a value known as the forward delay (default is 15 seconds and set by the root bridge). Topology Change Notification (TCN) BPDUs are used to inform other switches of port changes. TCNs are injected into the network by a non-root switch and propagated to the root. Upon receipt of the TCN, the root switch will set a Topology Change flag in its normal BPDUs. This flag is propagated to all other switches to instruct them to rapidly age out their forwarding table entries.

## ***Managed Switch STP switch port states***

Managed Switches go through various Ethernet port states depending on the situation:

- Listening - The switch processes BPDUs and awaits possible new information that would cause it to return to the blocking state.
- Learning - While the port does not yet forward frames (packets) it does learn source addresses from frames received and adds them to the filtering database (switching database)
- Blocking - A port that would cause a switching loop, no user data is sent or received but it may go into forwarding mode if the other links in use were to fail and the spanning tree algorithm determines the port may transition to the forwarding state. BPDU data is still received in blocking state.



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- Forwarding - A port receiving and sending data, normal operation. STP still monitors incoming BPDUs that would indicate it should return to the blocking state to prevent a loop.
- Disabled – Not strictly part of STP, a network administrator can manually disable a port.

## ***"Enhanced" Versions of STP -RSTP and MSTP***

Obviously there are many complications and data transmission delays associated with Spanning Tree Protocol. To prevent the delays when connecting hosts to a switch and during some topology changes, Rapid STP was developed and standardized by IEEE802.1w which allows a switch port to rapidly transition into the forwarding state during these situations. The Multiple Spanning Tree Protocol (MSTP), originally defined in IEEE802.1s and later merged into IEEE802.1Q-2003, defines an extension to the RSTP protocol to further develop the usefulness of virtual LANs (VLANs). This "Per-VLAN" Multiple Spanning Tree Protocol configures a separate Spanning Tree for each VLAN group and blocks the links that are redundant within each Spanning Tree. Using Managed Switches with STP and VLANs adds more administrative complexity.

## ***What Happens When Spanning Tree Protocol Is "Wound Too Tight"***

In an effort to decrease ring recovery time, some vendor's STP implementation tighten timer parameters. This can actually cause more problems than it solves. When these Ethernet switches detect network issues in overloaded networks or situations with many runt packets, they can overact. The STP-based Ethernet switches will attempt to correct the perceived problem. This causes parts of the network to bounce or thrash and application data may be lost.

## ***Hop Limitations of STP vs. Intelligent Quasar Technology***

STP has a limitation of 7 hops through a spanning tree. This limits the number of switches that can be connected together. The Intelligent Quasar ring technology does not have limits on the number of hops through a ring or connected rings. IQ1000 Switches provided greater deployment flexibility.

## ***Change/ Moves/ Adds on STP vs. IQ Ring***

When you add a device on a Managed Switch using STP an IT administrator needs to assign the device attributes and networking parameters prior to the device becoming operational. When you add a device on a Self-Managed switch, the device is automatically added to the IQ Ring and can begin communicating with other devices.



## ***Drawbacks of using Spanning Tree Protocol for Ring Topologies***

All of this background on STP/ RSTP /MSTP was provided to show:

- Spanning Tree Protocols are complex and difficult to manage
- STP-based networks are slow to initialize and slow to re-establish
- With Spanning Tree, one of the switches in the ring is administered to be the Root Switch. If this switch has problems it becomes a single point of failure in the ring network.
- STP uses a Listen, Learn, Forward and Block processes. This process can be very lengthy especially with complex network topologies.

Many of the drawbacks using STP can be found in the Cisco Tech Brief "*Spanning Tree Protocol Problems and Related Design Considerations*". This 19 page document describes many complex issues to be faced by users of Managed Switches. One quote from this paper issues a strong message of caution: "*Unfortunately, there is no systematic procedure to troubleshoot an STP issue*".

These issues can be avoided through the use of the IQ1000.

## **IQ1000 Self-Managed Switches are designed for Ethernet Rings**

As a Self-Managing Switch, the IQ1000 is not a Spanning Tree Protocol networking device. The IQ1000 uses Intelligent Quasar technology that utilises a distributed random ring-master algorithm. If one switch becomes inoperable or is isolated by fibre failures, the entire ring recalculates and a new master is rapidly assigned. An unconnected or inoperable IQ1000 is auto-isolated. The IQ1000 Smart Switch utilizes circuitry and software algorithms that surround the Ethernet switch chip to create an environment that is logically isolated from the IP Data traffic. The following table demonstrates the advantages of Self-Managed Ethernet Switches:



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Ethernet Switch Technology Comparisons			
Feature	Unmanaged	Managed	Self-Managed
Customize network performance	no	yes	no
Easy Installation	yes	no	yes
Time to install	~10min	~1hr	~10min
Special networking skills required	no	yes	no
Redundant path recovery time	n/a	1-10min	1-10sec
Redundant path switch hops	n/a	no	yes
Automatic redundant path determination	easy	difficult	easy
Network expansion i.e. adding IP appliances	yes	no	yes
Plug-and-Go	yes	configured	yes
Auto-negotiate port speed	none	Spanning Tree	Intelligent Quasar
Redundant protocol utilized	n/a	No, STP fails	yes
Mission critical redundancy	fast	slow	fast
Switch recovery after power required	no	yes	no
SNMP support	no	yes	no
VLAN support	no	yes	no
IP multicasting support	no/all ports	yes	no/all ports
QoS support	no	yes	no, fair weighted queue
Bandwidth rate limiting support	no	yes	no, full wire speed
Network downtime due to repair/maintenance	minimal	excessive	minimal

## Self-Managed IQ1000 vs. STP-based Managed Ethernet Switch Highlights

1. When IQ1000 switches are connected in a ring, Intelligent Quasar technology automatically creates the ring transport without any need for IT administration.
2. Since the IQ1000 does not use STP with BPDUs - none of the multi-second to several minute set-up times described earlier with STP are experienced.
3. Using Intelligent Quasar technology obviates the need for the STP switch port states and all the associated delays.
4. IQ 1000 Self-Managed Switches guarantee high availability and rapid network recovery.
5. An IQ Ring is deterministic. This can not be accomplished through Spanning Tree Protocol. STP uses Broadcast Packet Data Units (BPDUs) that are transmitted to all devices.

04/05/2007

8

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6. Since this Intelligent Quasar technology is not part of the switch, but is part of the IQ Ring it can act independently to provide the resiliency and ring recovery speed that is not found in other vendor's Ethernet switching equipment.

## **IQ Rings Provide "Armoured" Data Paths**

Because the IQ1000 switch does not have an IP address, it can not be altered in any fashion by internal or external personnel. This means the IQ1000 switch can not be hacked. The data streams from the IP devices attached to the IQ1000 can not be rerouted or modified. Therefore, these data streams are protected from any intrusion. Furthermore, since the IQ ring is self-healing all data streams are delivered uninterrupted.

## **Be Wary of Mis-leading Ring Recovery Time Advertisements**

How fast an Ethernet ring recovers is an important performance parameter, and it's not surprising that many Ethernet Switch vendors lead their sales pitch with their ring recovery capabilities. There are many ways to report this information and it is often difficult to ascertain the truth.

Some vendors talk about 5-10msec recovery times, others speak of 38msec recovery times. Note that it takes about 100msec for an Ethernet PHY chip to reinitialise. In many cases these vendors are stating the time it takes to establish whether the ring is connected or whether it broken. These very short timing intervals are not the intervals it takes to have application data flowing on the ring. The real measure of ring recovery is the interval from when payload data is interrupted on the ring to when this data is flowing again.

Note that there is a restoral time for ring transport to recover from a ring break, and a longer restoral time for the applications that run over the ring. IQ1000 Self-Managing Switches have superior ring recovery times compared to STP-based Managed Switches



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## Self-Managed Switches have Superior Return on Investment

There are 5 cost factors that should be used when preparing an ROI analysis for an Ethernet Switch network:

1. **Cost of Network Failure** - what are the costs when the network goes down and is inoperable for a period of time.
2. **Cost of Equipment Acquisition** - the initial equipment purchase cost.
3. **Cost of Expertise** - the level of technician that can be used and at what level of pay/hour.
4. **Duration of Installation time** - the length of time to install a unit and the length of time to install a network.
5. **Total Cost of Ownership** - equipment reliability, ease of change/move/adds, ease of equipment upgrades.

***Self-Managed Ethernet switches have superior Return on Investment when these factors are taken into account.***

## Summary - Compare Technologies and Choose Carefully

Network designers are looking for improved ways to build resilient IP-based Ethernet networks for critical applications such as Video Surveillance, Security and Building Automation. In order to achieve significant network performance improvements Self-Managed Ethernet switches must be seriously considered. The numerous advantages Self-Managed switches provide the ideal mix of ease-of-use, network reliability, cost-effective deployments and future flexibility. The use of IQ Rings should be examined in all network situations where network resiliency and rapid recovery are critical.