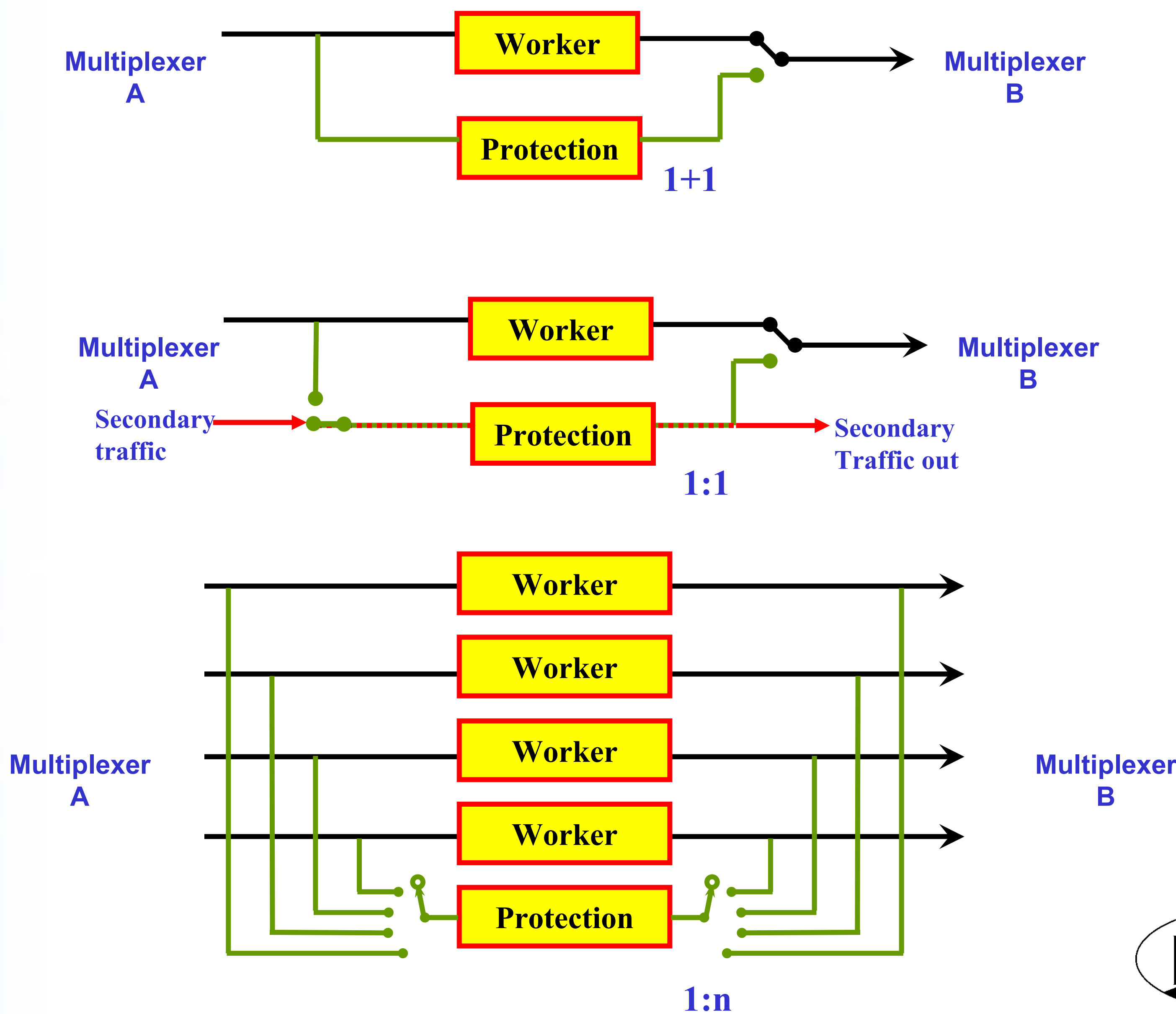
Advanced SDH
Protection and Synchronisation

Chapter 2
Multiplexer Trail Protection

MS Trail Linear Protection



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MS Trail Linear Protection

NOTES

Several flavours of Line or Span protection exist.

1 + 1 – the source is permanently bridged to the protection trail but the sink at the end of the link is bridged.

1 : 1 – the source and sink are both switched

1:N – one protection path exists for many working circuits.

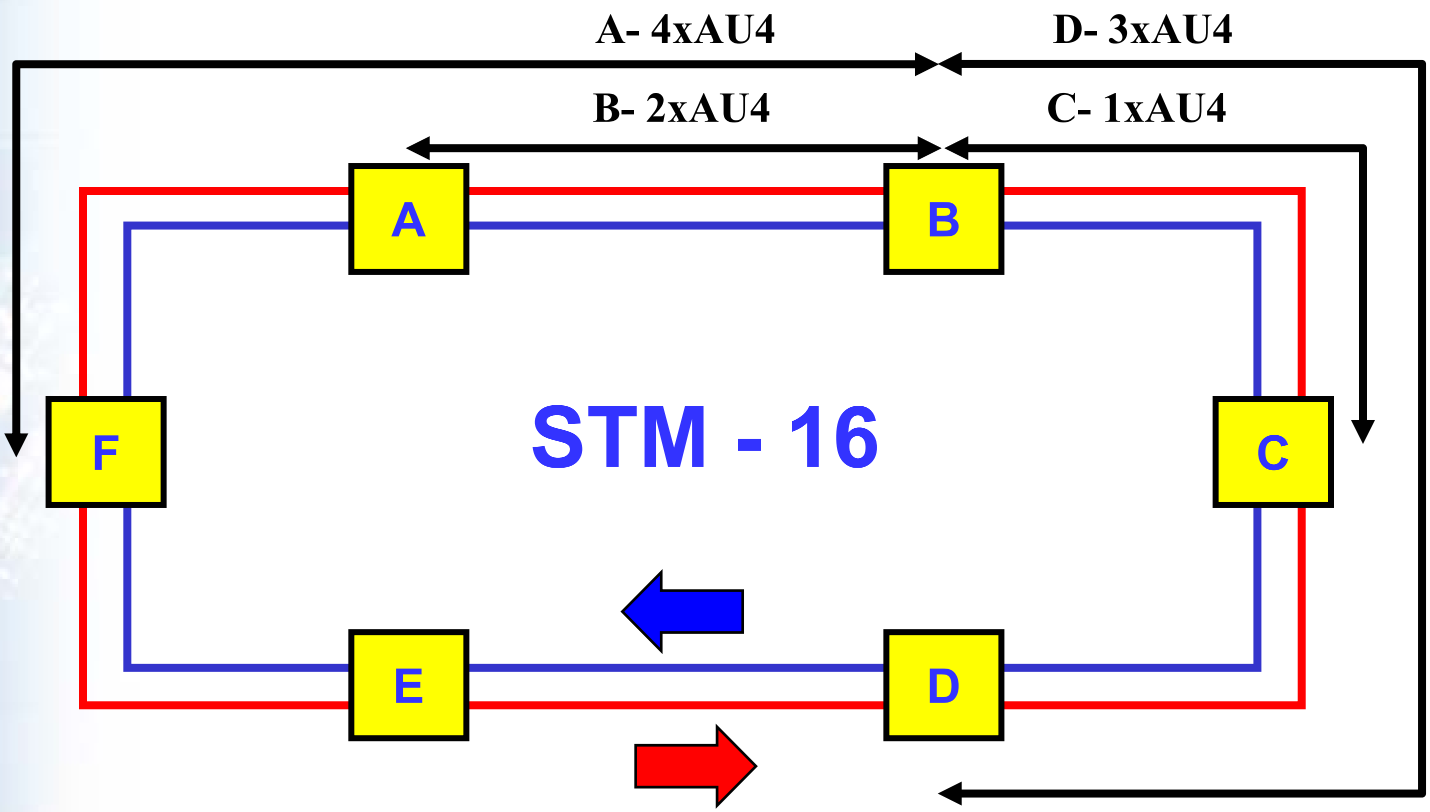
The actual switching function itself is undertaken by the APS protocol held within bytes K1 and K2 of the MSOH.

Protection paths make use of pre-assigned capacity between nodes. The simplest architecture has one working and one protection channel (1+1), The most complex architecture has n working channels and m protection channels (m:n). A 1:n protection architecture has n normal working traffic signals and 1 protection traffic signal.

The signals on the working are the normal traffic signals The signal on the protection may either be one of the normal traffic signals, an extra traffic signal, or a null signal (e.g. an all ones signal or a test signal).

When a defect condition is detected on a working channel, or under the influence of certain external commands, the transported signal is bridged to the protection path. At the receiving end the signal from the protection path is selected instead of the original failed working connection.

2 Fibre MS-SPRING



Protection (8 AU-4s)

Worker (8 AU-4s)

- Maximum of 48 x VC4 Connectivity In this example

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2 Fibre MS-SPRING

NOTES

Multiplexer Section – Shared Protection Ring is another protection mechanism. This tends to be used on higher level metropolitan or core SDH rings, this is because in order to realise the full advantages of MS-SPRING, traffic must be propagated between various nodes on the ring. In lower speed, lower level SDH access rings all traffic tends to be focused to and from the head-end node, exhibiting a single hub traffic profile, and so the advantages of MS-SPRING would be lost.

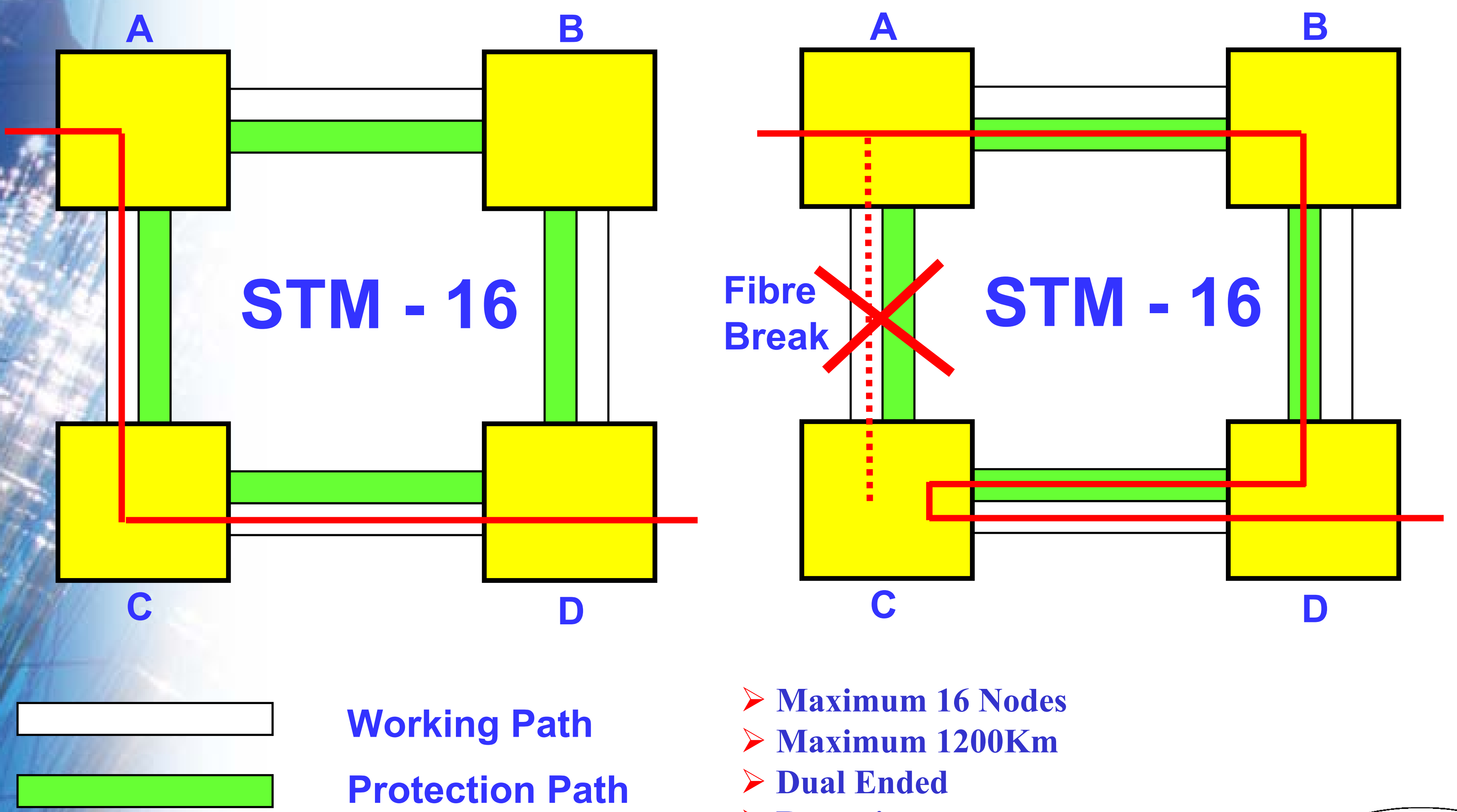
MS-SPRING is also known as Bidirectional Self Healing Ring (BSHR) – however, this is simply another name for it, the actual operation is exactly the same. Each AU-4 propagating around the ring may be referred to as a timeslot.

The principle behind MS-SPRING is this. All traffic around the ring is protected on Span by Span basis. 50% of bandwidth on every span must be reserved for protection. A maximum of 16 nodes may exist in any single ring.

In my example traffic paths are required between A-B, C-D and E-F. Within my STM-16 I have 8 worker STM-1's and 8 protection (these may be used optionally for extra traffic if required). Between A-B I can allocate 8 STM-1s, between C-D I can allocate 8 STM-1s, between E-F I can allocate 8 STM-1s – suddenly my STM-16 has a capacity of STM-24, simply because of my traffic profile around the ring, all traffic is terminated at each node. In a best case scenario (which in reality would never happen), I can allocate 8 STM-1s between A-B, B-C, C-D, D-E, E-F and F-A rendering a theoretical bandwidth of STM-48!!

Should a single failure occur, a protection path exists around the ring for up to 8 STM-1s so the ring can continue to function until full network restoration has occurred. MS-SPRING not only accommodates transmission failures, but also nodal failures.

2 Fibre MS-SPRING



- Maximum 16 Nodes
- Maximum 1200Km
- Dual Ended
- Revertive

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2 Fibre MS-SPRING

NOTES

The network objectives of MS-SPRING define it's characteristics. These are;

Number of Nodes – The maximum number of nodes is determined by the APS protocol, responsible for managing the switching process. The APS numbers nodes from 0-15, so a maximum of 16 nodes may be present in any MS-SPRING.
Switching Time – This is a function of the APS protocol which according to G.841, should be less than 50MSec.
Secondary Traffic – It is possible to allow secondary or extra traffic to propagate around the MS-SPRING on the protection path. This would be low priority traffic and would be pre-empted immediately should a failure occur.
LO VC Access – it is quite possible for any node to add or drop LO order traffic into or out of the ring. The LO VCs would of course be mapped into a HO VC, which would be protected around the ring.
Extent of Protection – the ring should restore traffic from any single failure without any problem at all, however in the presence of multiple failures ring segmentation may well occur.
Switching Type – All switching will be dual ended.
APS Protocol – This will be employed using the K bytes of the MSOH as this manages the switching and bridging operations in the event of a failure.
Operation Mode – All MS-SPRINGs are revertive in operation, that way a protection path is always available irrespective of where the fault occurs within a ring.
Physical Size of Ring – This is limited to 1200Km in order to ensure that the switching time aims remain realistic.
Upgradeability – It should be possible to insert or remove nodes from an MS-SPRING without a problem, subject to the minimum and maximum node number constraints.
Manual Control – A high degree of manual control should be possible and commands may be issued via craft terminal or element manager. These controls would include;
Clear – Removes all externally generated requests and wait to restore.
Lockout of Working Channels – Blocks working channels access to the protection channels.
Forced Switch – Forces working channels onto protection channels.
Manual Switch – Forces working channels onto protection channels provided protection channels are serviceable.
Exerciser – Performs a protection switch without actually switching any traffic.

In the slide example the fibre breaks between nodes A and C. On detection of this, Nodes A and C perform a "Ring Switch", this switches all the affected traffic paths on to the protected paths in the opposite direction. When the protected traffic arrives at Node C (where a ring switch has been undertaken), it turns back on itself to be terminated at Node D on the normal working path.

Switch Initiation Criteria

Externally or Automatically Generated Requests to Switch

Externally Generated Requests (Craft Terminal or Element Manager)

Commands not issued on the APS Signalling Channel

- Clear
- Lockout of Working Channels – Ring Switch

Commands issued on the APS Signalling Channel

- Forced Switch of working to protection channel –Ring (FS-R)
- Manual Switch of working to protection channel – Ring (MS-R)
- Exercise-Ring (EXER-R)

Automatically Generated Requests

- Signal Fail (SF) - Hard Failures – LOS, LOF, LOP, MS-AIS
- Signal Degrade (SD) – Soft Failures – Error Performance
- Reverse Request (RR) – Sent as acknowledgement to SF or SD
- Wait To Restore (WTR) – Prevents Oscillations

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Switch Initiation Criteria

Requests to switch to the backup path may initiated externally, perhaps for maintenance purposes, or it may be generated automatically in response to prevailing network conditions.

The externally generated requests may be further divided into requests which employ the APS signalling channel and those that do not.

External Commands which do not employ the APS signalling channel;

Clear – This command clears all externally generated requests and Wait To Restore at the node to which the request is sent. Following this request everything is back to the default state with No Request (NR) generated within the K1 Byte of the APS protocol.

Lockout of Working Channels – This command prevents the channels on a selected span from getting access to the protection path. It does seem an odd thing to want to do, however, in circumstances where there is only low priority traffic on a span, or where there is a particularly intermittent route it may be useful.

External Commands which do employ the APS signalling channel;

Forced Switch of Working to Protection – Ring (FS-R) – This command performs the ring switch from working channels on a selected span. This command has the highest priority of any command and so the working channels will switch irrespective of the state of the protection channels.

Manual Switch of Working to Protection – Ring (MS-R) – This command does exactly the same the as the previous command, however it is slightly lower priority. This means that the switch to protection channels will only occur if the protection channels are in an acceptable working condition.

Exercise (EXER-R) – This command makes a Ring go through the process of switching to protection channels without actually making the switch.

Automatically Initiated Commands

Signal Fail (SF) – This command is issued once certain alarm conditions reflecting a "hard failure" have been detection. Hard failures would be such things as a broken fibre. The actual alarms conditions which would generate a hard failure include; Loss of Signal (LOS), Loss of Frame (LOF), Loss of Pointer (LOP) and Multiplexer Section – Alarm Indication Signal (MS-AIS).

Signal Degrade (SD) – This command is issued once certain alarm conditions reflecting a "soft failure" have been detected. Soft failures are not physical failures, but represent a drop in the expected quality of a connection, typically because the BER Threshold (measured from the BIP checks) has been exceeded.

Reverse Request – This is issued on two occasions. It is issued in response to an SF or SD to acknowledge receipt in the opposite direction. As MS-SPRING is a revertive protection mechanism, it is also generated once a fault has cleared to switch traffic back on to the working paths.

NOTES

Wait To Restore – This is issued in revertive protection schemes to prevent oscillation in the event of instability on the working paths. Once WTR expires the revertive switch is made.

MS-SPRING Capacity

No of Nodes	2 Fibre MS-SPRING Capacity
2	-
3	24
4	32
5	40
10	80
12	96
15	120
16	128
17	-

No of Nodes	SNCP
2	16
3	16
6	16
12	16
24	16
∞	16

|Note – For Maximum Capacity to be achieved, all Nodes would have to exhibit "site to adjacent site" Traffic profile

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MS-SPRING Capacity

NOTES

One of the great advantages of MS-SPRING is not simply that it gives high levels of protection. One of the other advantages in areas, where the traffic profile is either Uniform or Site to Adjacent Site, the availability of bandwidth is much increased.

Even in a worst case scenario when all traffic propagates between to two most distant nodes, the capacity matches that of a standard ring architecture where another protection scheme such as VC-Trail or SNCP is employed – so really there is nothing to loose by employing MS-SPRING and potentially plenty to gain.

In order to work out the maximum capacity in a best case scenario (which means a traffic profile of "site to adjacent site") simply work out the available bandwidth on a span, in terms of AU-4s, remembering to divide the total capacity by 2 for reasons of protection and multiply that by the number of nodes.

For example – I have 6 nodes in an STM-16 ring – how many VC-4s are available around the ring?

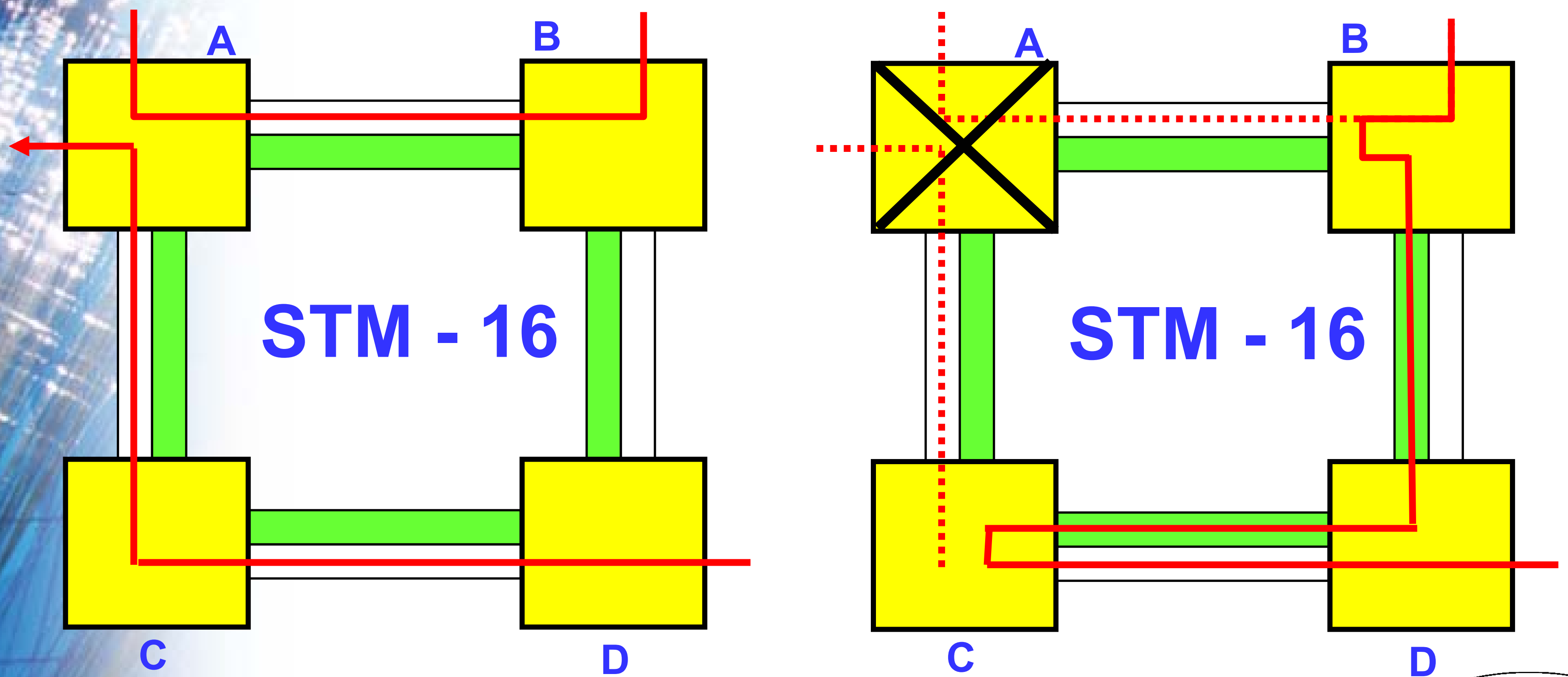
Half of STM-16 gives 8xVC-4.

So..8x6 (number of nodes) = 48xAU-4.

The only thing to remember really is that there is a minimum requirement of 3 nodes in a ring and a maximum of 16.

Traffic Misconnection

- Misconnection only a danger when nodes become isolated
- Squelching will ensure misconnections are avoided
- An alternative to squelching is to enable TTI at the AU-4 level detect TTI Mismatch (TIM) and insert AIS upon detection of mismatch



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Traffic Misconnection

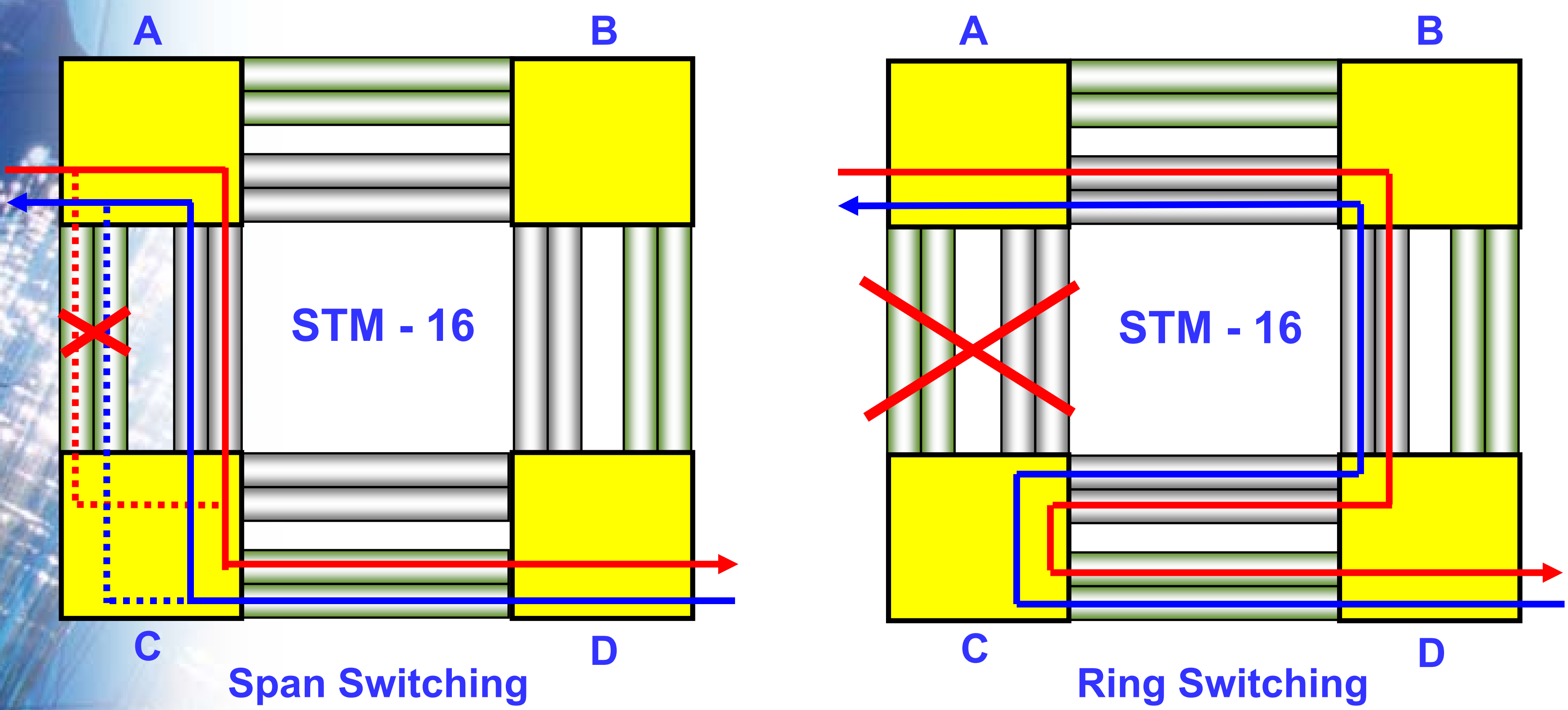
NOTES

If a failure occurs within MS-SPRING whereby a node becomes isolated due to the nature of the fault, it is possible that "misconnections" can occur. A misconnection results from a situation where two traffic channels end up competing for the same time slot on a span. Remember, within MS-SPRING the response to a failure is to ring switch away from a fault and on to protection channels. So in the case on the slide, any traffic destined for node A, is never going to get there as Node A has effectively been removed from the network. This traffic is likely as a result of protection switching therefore to arrive elsewhere where it is not expected, or wanted.

Squelching is a process whereby nodes may recognise that a node has become isolated within a ring and therefore suppress any traffic originating on their node to the isolated node, by inserting AU-AIS on all the channels affected. That way only traffic which is destined to a live destination is active on the ring. In order for squelching to work a node has to have an active and accurate Ring Map, and a Connection Table indicating which connections originate and terminate and pass through on the node, and a squelch table which identifies the node addresses at which each AU-4 enters and exits the ring.

An alternative to squelching is to ensure that TTI is set up on each AU-4. Should there be a mis-connection, then the TTI on the arriving AU-4 will be different. On detection of this a Trail Identifier Mismatch (TIM) alarm is generated and as a result of this the affected channel could have AU-AIS inserted (undertaking the same function as squelching).

4 Fibre MS-DPRING



Separate Fibre Pairs used
For working and protection
paths

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4 Fibre MS-DPRING

NOTES

4 Fibre MS-DPRING is more robust and resilient than 2 Fibre MS-SPRING. As you can see from the diagram two fibres are used for the working path transmit and receive and two are used for protection so we still have a 50% bandwidth split. MS-DPRING is also known as Unidirectional Self Healing Ring (USHR).

The advantage of 4 Fibre MS-SPRING is that it can undertake two forms of protection switching, span and ring, plus twice the bandwidth supported by MS-SPRING is supported by MS-DPRING.

In the first example, only a partial failure has occurred on the working path, however the protection path is still operational. A span switch therefore occurs, which you have already seen described as line switching. The working path only propagates over the protection path on that particular span only – the rest of the ring is unaffected.

In the second example the complete link fails between nodes A and C, Nodes A and C therefore carry out a ring switch which loops the working paths back over their protection paths. Notice that between nodes C and D the working span is used, as if no problem had occurred. On arrival at node C a loop is experienced which forces the traffic around the ring in the opposite direction to the destination node A.