Link Aggregation - IEEE 802.3ad

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Based on chapter 8 of:
M. Baldi, P. Nicoletti, "Switched LAN", McGraw-Hill, 2002, ISBN 88-386-3426-2

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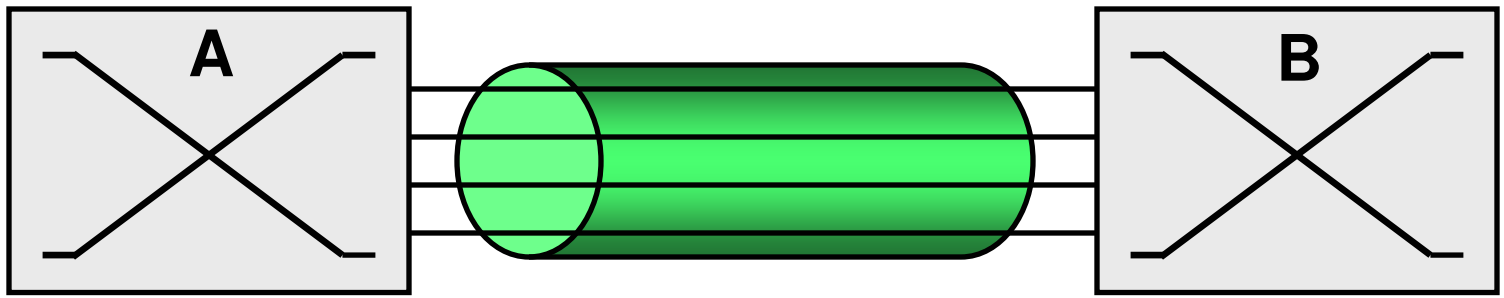
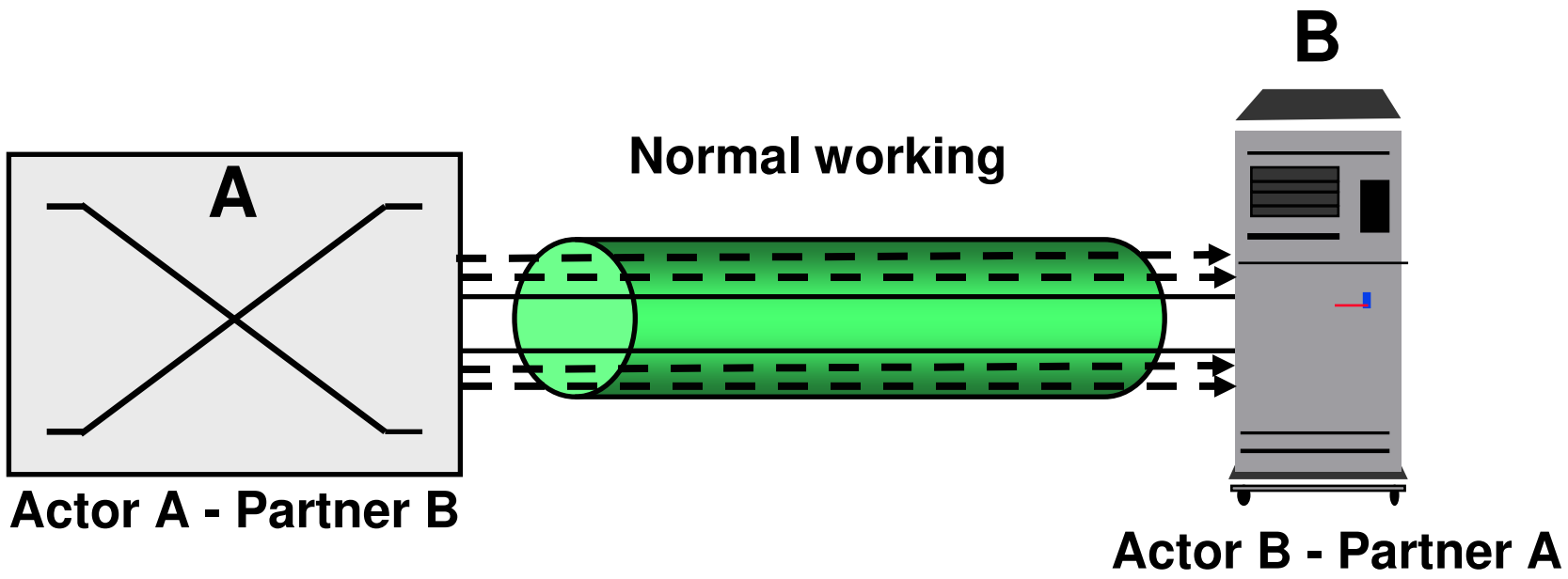
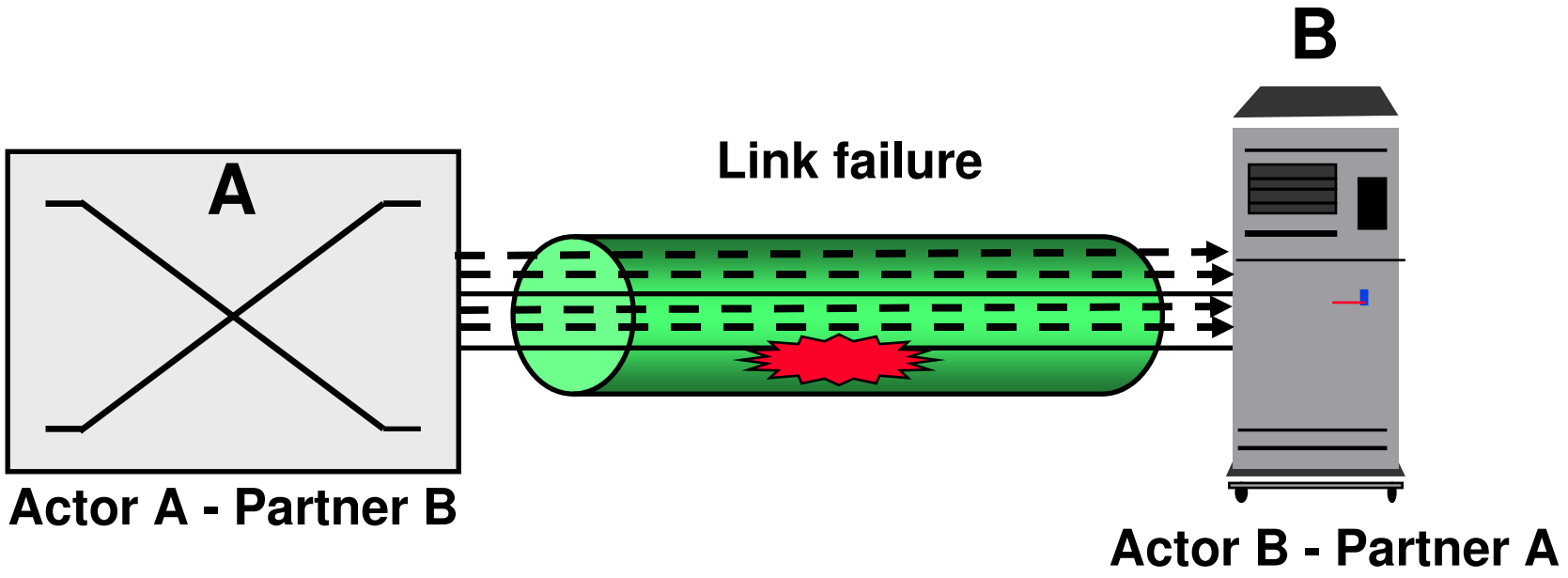
IEEE 802.3ad

- Standard which replaces proprietary solution to group/aggregate more ports
  - useful to increase bandwidth
  - It's able to manage efficiently redundacy link between two network devices
  - normally used on link between switches, seldom between switch and computer







802.3ad details

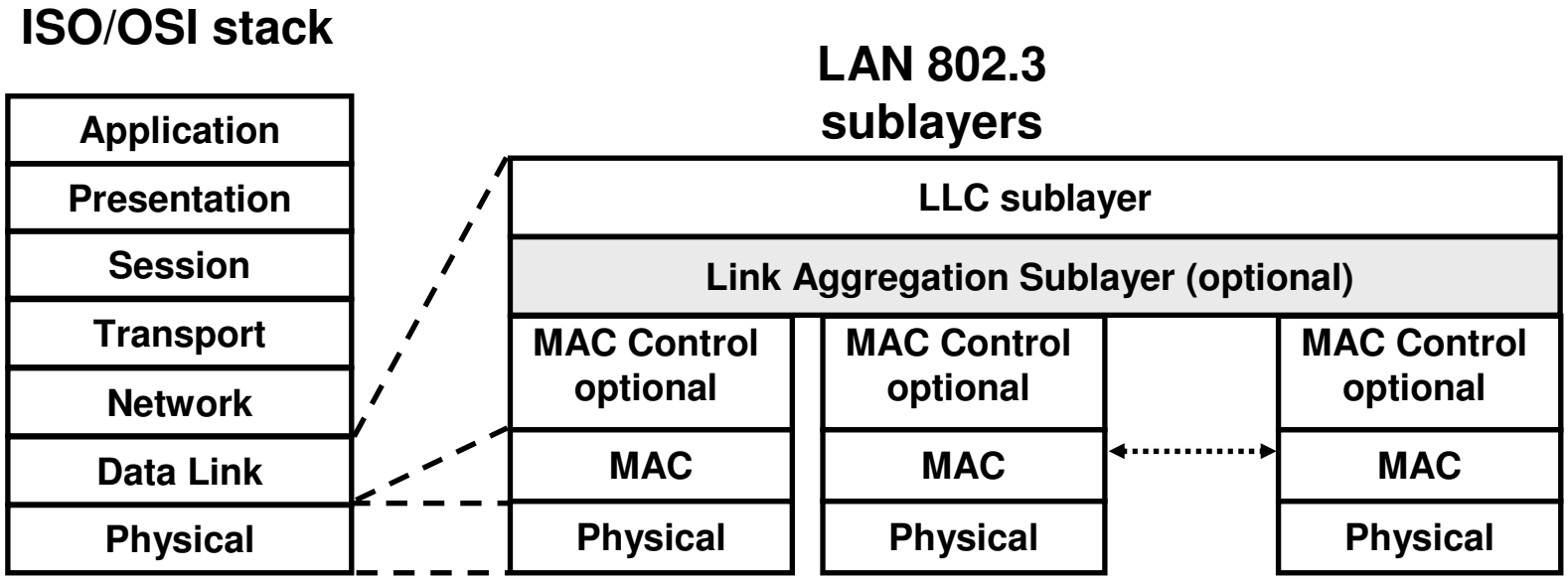
- Link aggregation is possible only on full duplex links
- Band increasing
  - Multiple link are grouped in a logical link
  - Bandwidth grow up is incremental
- Load sharing
  - Client's traffic can be shared out on multiple link
  - Increased reliability
  - link failure in an aggregation set doesn't affect comunication between partners at the edge

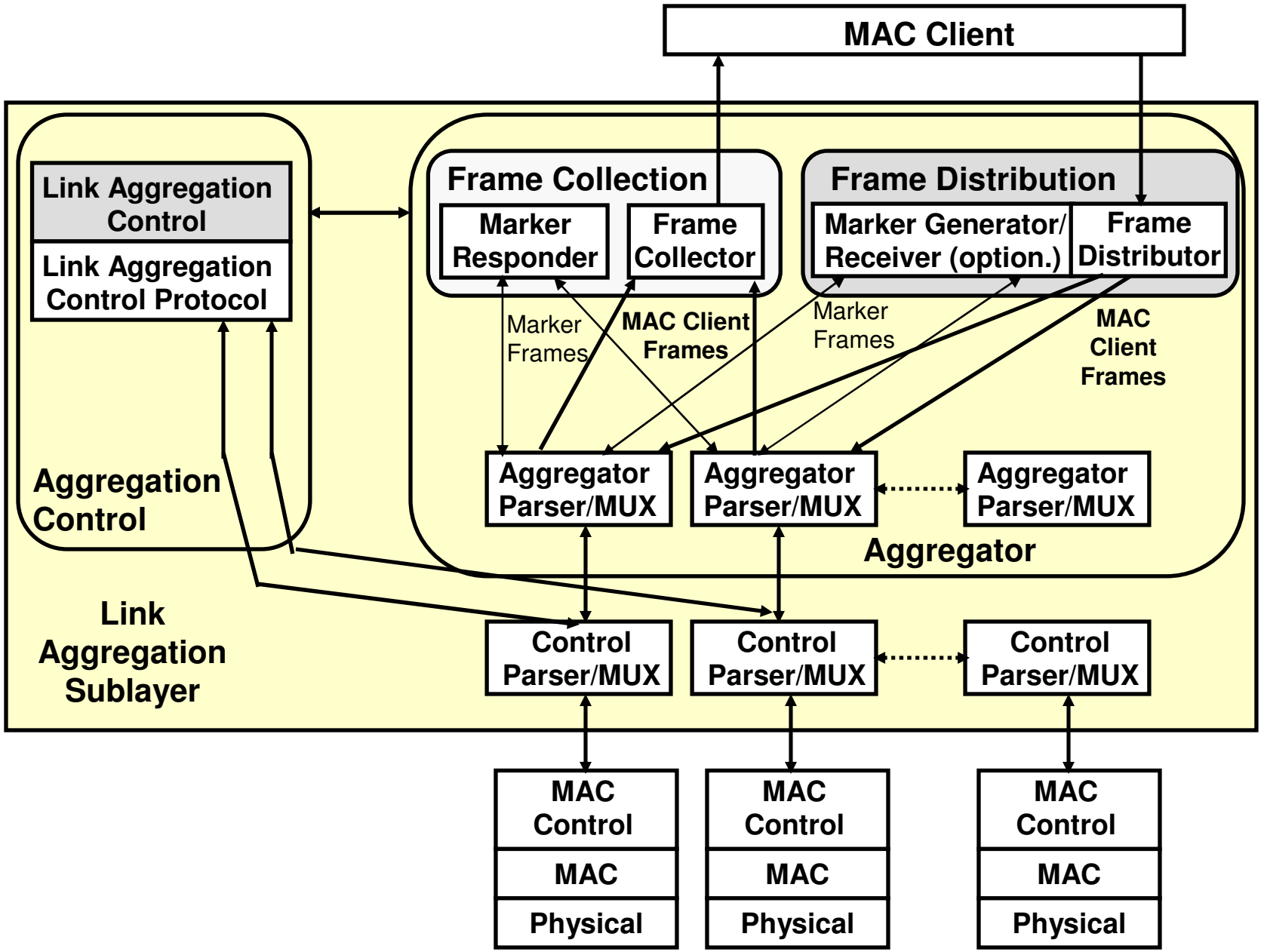
802.3ad details

- Fast convergence
  - aggregation set can converge in a new configuration in less than 1 second
- Every physical link within an aggregation group must have same speed
- Automatic aggregation configuration through LACP (Link Aggregation Control Protocol)
  - Multicast transmission of LACPDU

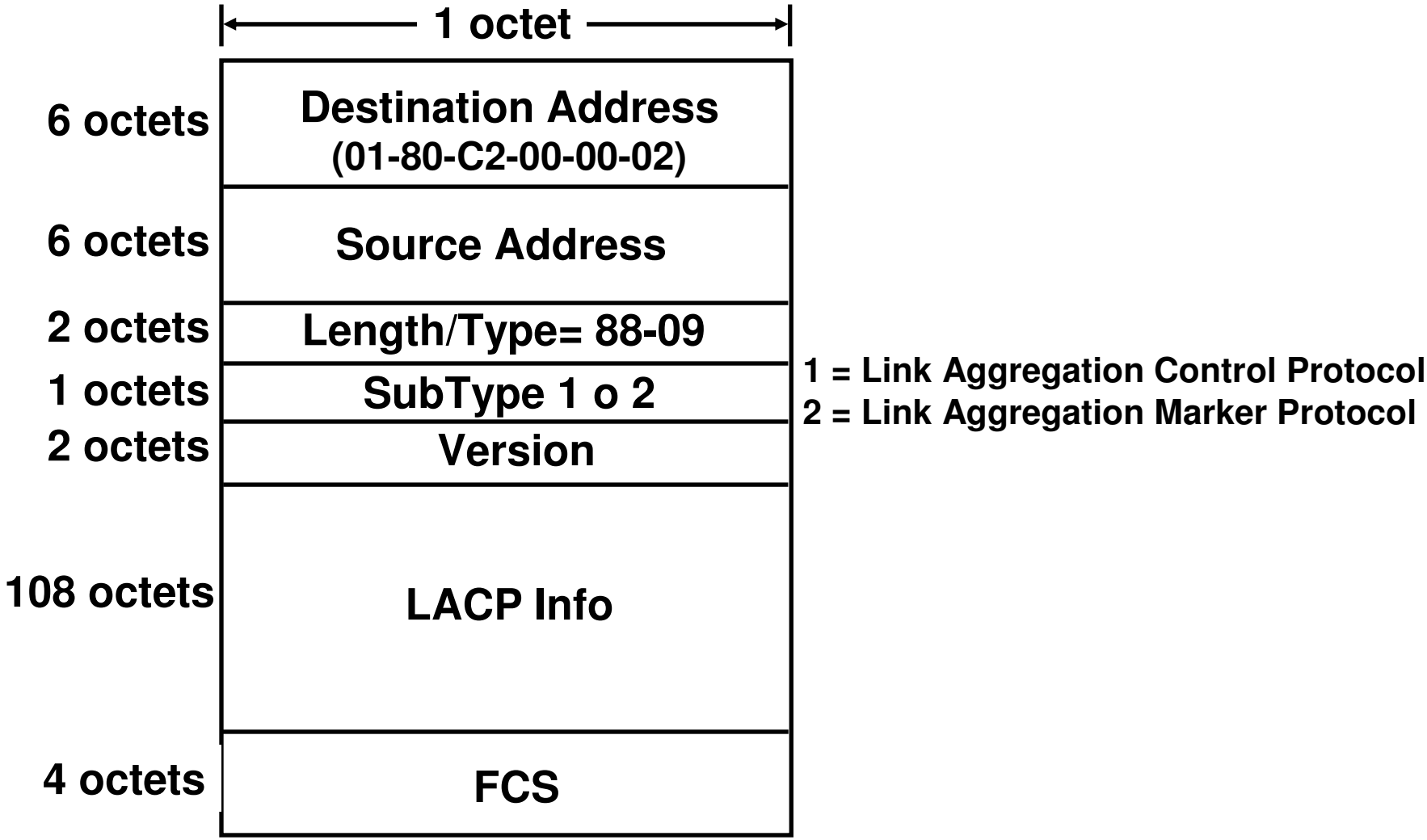
802.3ad and OSI layer

- Link aggregation sublayer is inserted between LLC level and MAC layers of the single ports to aggregate





LACPDU



Link Aggregation Group Identifier (LAG ID)

- Used to automatically verify if two ports of a link share the same membership group
  - Complete LAG ID is made up of a local and remote LAG ID
    - Actor LAG ID is the local one
    - Partner LAG ID is the remote one

Link Aggregation Group Identifier (LAG ID)

- LAG ID has the following parameters:
  - System Identifier (System Priority + MAC Address)
  - Operational Key assegned to ports in the LAG
  - Port Identifier (Port Priority + port number)
    - Unnecessary parameter in some cases, if so it is set to zero

Link Aggregation Group Identifier (LAG ID)

- To establish the membership at the same aggregation group between two ports of a link, local (actor) and remote (Partner) LAG ID are written in LACP packet
  - S e T variable for local and remote System ID
  - K e L variable for local and remote Operational Key value
  - P e Q variable for local and remote Port ID

Example of Partner parameter to build the complete LAG ID of a link

	Partner SKP	Partner TLQ
System Parameters (S, T)	System Priority = 0x8000 (see 43.4.2.2) System Identifier = AC-DE-48-03-67-80	System Priority = 0x8000 (see 43.4.2.2) System Identifier = AC-DE-48-03-FF-FF
Key Parameter (K, L)	Key = 0x0001	Key = 0x00AA
Port Parameters (P, Q)	Port Priority = 0x80 (see 43.4.2.2) Port Number = 0x0002	Port Priority = 0x80 (see 43.4.2.2) Port Number = 0x0002

The complete LAG ID derived from this information is represented as follows, for an Individual link:

[(SKP), (TLQ)] = [(8000,AC-DE-48-03-67-80,0001,80,0002), (8000,AC-DE-48-03-FF-FF,00AA,80,0002)]

Packets distribution on aggregate ports

- Standard doesn't define an algorithm to distribute packets to the port
  - No packets segmentation and reassembling
  - More conversations over a port
  - A conversation can be moved to an another port because of load balancing or *link failure*
  - Aggregation can have one or more link
  - Standard lists possible packets distribution criteria over ports

Packets distribution on aggregate ports

- Standard doesn't define an algorithm to distribute packets to the port
  - Two switches of different vendors can use different packets distribution algorithms
    - it can not be working
    - distribution could be not optimal
  - It will be better if switches at the edge of an aggregation link belong to the same vendor

Packets distribution on aggregate ports

- Conversation are assigned on:
  - Source MAC Address
  - Destination MAC Address
  - Receiving port
  - Destination kind (singlecast, multicast, broadcast)
  - Length/Type value
  - Higher Layer Protocol (for example 4 Layer ports)
  - Mix of previous criteria

Cisco distribution criteria

MAC address pairs **Source and Destination**	**Last** **2 bit**	**X-OR** **result**	**Chosen** **link**
Source MAC Address 00-00-00-00-00-01 Destination MAC Addr. 00-00-00-00-00-04	**01** 00	**01**	**Link 2**
Source MAC Address 00-00-00-00-00-02 Destination MAC Addr. 00-00-00-00-00-05	**10** 01	**11**	**Link 4**
Source MAC Address 00-00-00-00-00-03 Destination MAC Addr. 00-00-00-00-00-07	**11** 11	**00**	**Link 1**
Source MAC Address 00-00-00-00-00-06 Destination MAC Addr. 00-00-00-00-00-08	**10** 00	**10**	**Link 3**

Standby link

- Enables link to act as backup of other links
- Links belonging to two aggregation groups
  - Link with higher priority became active
  - Link with lesser priority became standby
- When the aggregable link number is *lesser* of the number of link between two switches (which share the same assigned administrative key):
  - link with higher priority are activated while the other are put in standby mode

Standby link and dynamic keys assignment

- Administrative key assignment to active link
  - Different keys for standby link and active link
  - standby link uses a new key but it keep trace of the active link's group key
  - in case of active link failure, a new aggregation group must be created. This group will exclude the broken link and will include the stand-by one
    - Key reassegnment for the new group

Dynamic keys assignament

- The two equipments use the same key on the port aggregation
- The key is assigned by the equipment that has the higher priority
  - priority criteria is the spanning tree one's
    - system priority (bridge priority if it is a switch) + MAC address
    - lower the value, higher the priority
    - Example: 8000-08-00-2B-50-20-00 has higher priority than 8000-08-00-2B-C4-E6-AA

Standby and equal level cost load sharing

- Assigned an unique administrative key for all ports; in practice ports are grouped together, although it is possible to group a smaller number of ports
  - Port can be active for a group and standby for another one
  - The higher priority aggregate become immediataly active using the administrative key
    - Priority = System-ID - Port ID
  - After a few seconds the lesser priority aggregate become active using another key

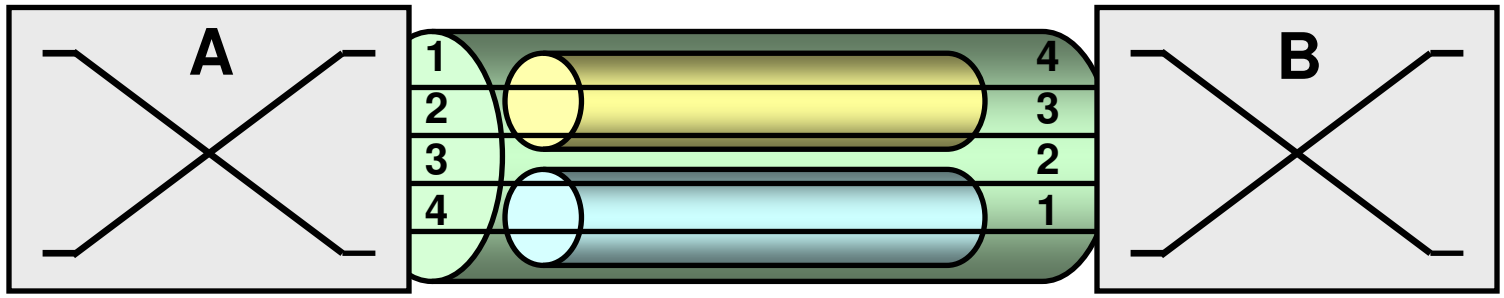
Example 1: standby and equal level cost load sharing

- Example 1: 4 parallel link, only 2 can be aggregate
  - Aggregation key = 1
- Switch A has higher priority
- Aggregation and backup rules on Switch A:
  - port 1 with port 2 or 4
  - port 2 with port 3 or 1
  - port 3 with port 4 or 2
  - port 4 with port 1 or 3

Example 1: standby and equal level cost load sharing

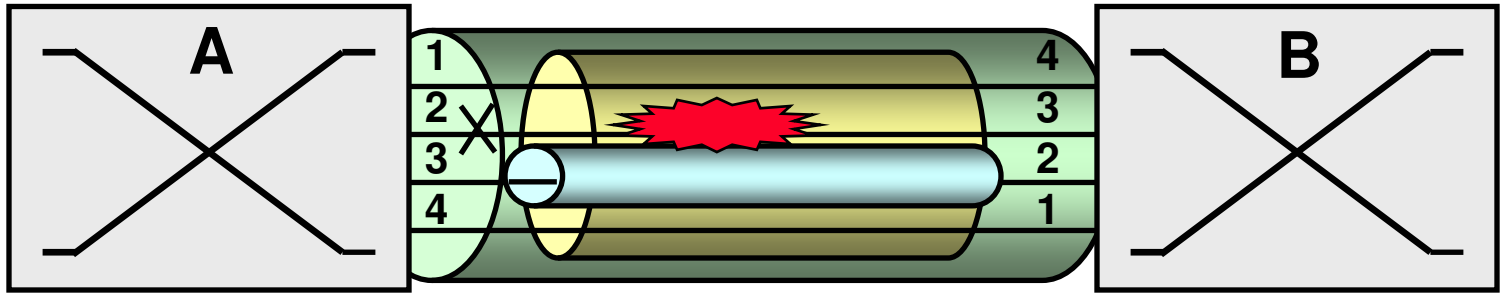
- The alghoritm:
  - select the 2 higher priority link as active
    - assign key = 1 to link A1-B4 and A2-B3
    - consider other link as standby
    - keep trace of key 1 on link A4-B1 and change the key on link A3-B2 and A4-B1
  - After few second it active link A3-B2 and A4-B1 as second port aggregate
  - load sharing on the two aggregate

Example 1: normal and fault conditions



Higher priority switch

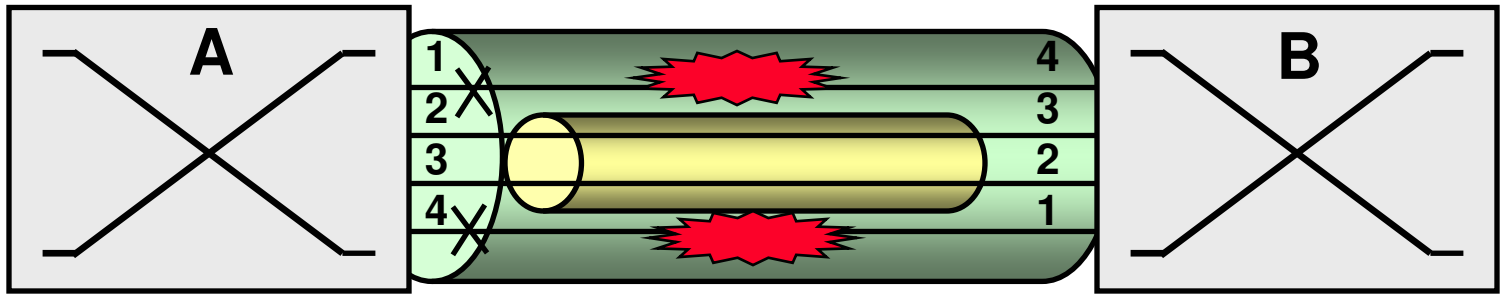
Normal working



Higher priority switch

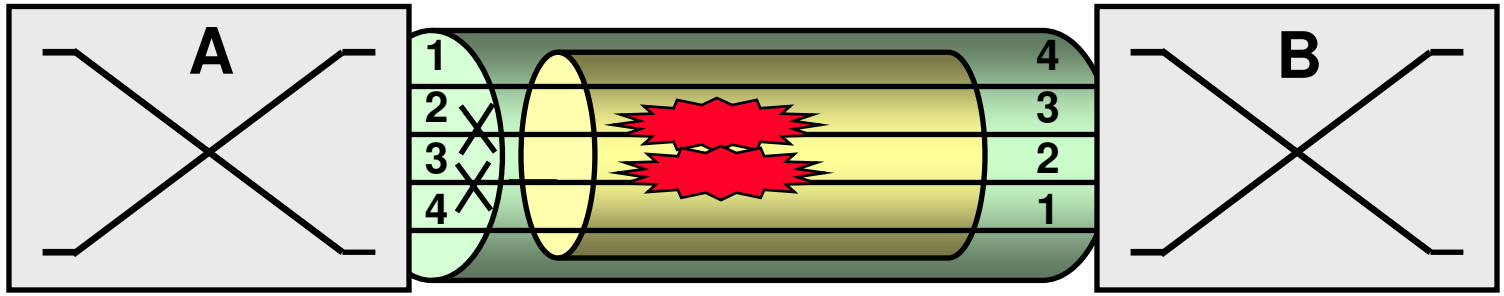
Failure on link A2-B3

Example 1: fault conditions



Higher priority switch

Failures on link A1-B4 and A4-B1



Higher priority switch

Failures on link A2-B3 and A3-B2

Link Aggregation and STP/RSTP

- It doesn't affect STP or RSTP
- We have to set Path Cost value to ports in order to reflect aggregate bandwith value
  - disable automatic path cost on ports
  - It will be better to use RSTP because has a wider range of Path Cost values

Link Aggregation and STP/RSTP