

WinnComm-SDR'11
**Routing pattern Selection for opportunistic
network management**

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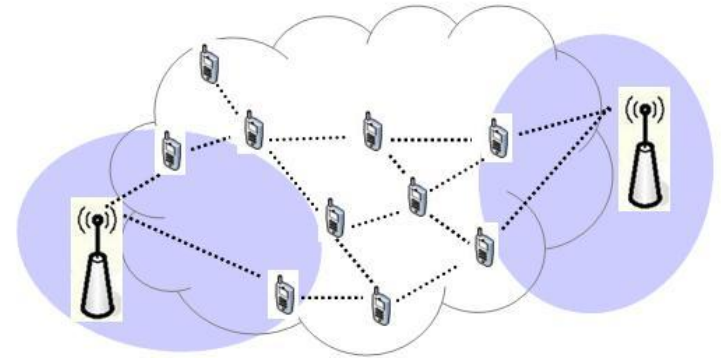
Context of opportunistic network (FP7 OneFit project [onefit])

- ◆ Multi Radio Access Technologies management with infrastructure and infrastructure-less networks.
- ◆ Radio resource optimization (cognitive radio)
- ◆ Standardization activities [ETSI RRS]






Focus on the optimization on the ad-hoc part of the Opportunistic network.

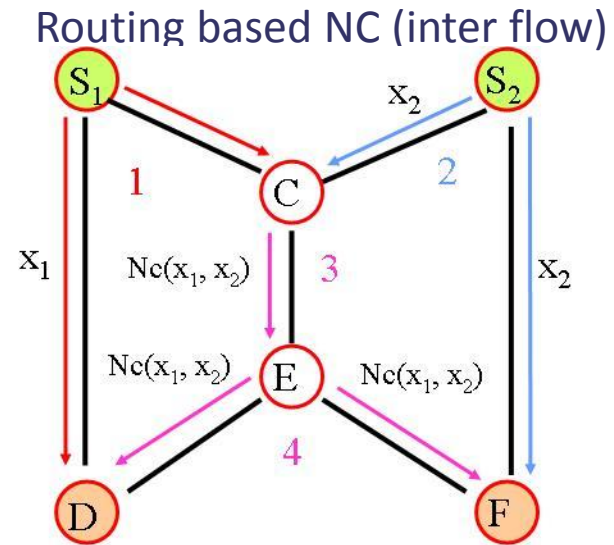
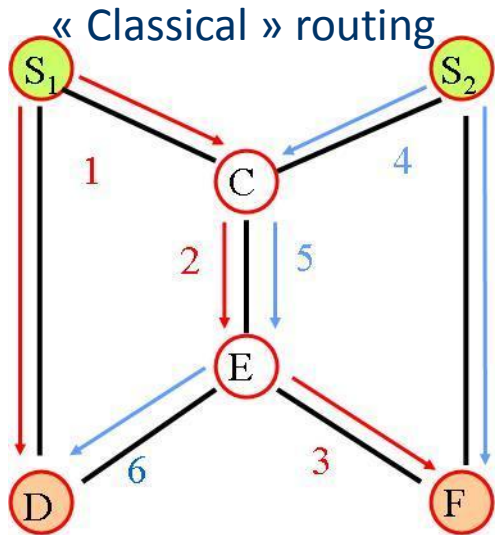
- ◆ Routing improvements
- ◆ Radio resources optimization
- ◆ Optimization on Multi flows combinations

Proposal : Use combination of network coding with routing protocols



[Yeung&all]

-  Radio node 
-  Traffic x_1 : from node S_1 to nodes D & F
-  Traffic x_2 : from node S_2 to nodes D & F
-  Linear combination of x_1 and x_2 packets



Principle

$Nc(x_1, x_2) = x_1 \text{ xor } x_2$

Size $(Nc(x_1, x_2)) = \text{size}(x_1) = \text{size}(x_2)$

D receives x_1 and, $Nc(x_1, x_2)$, D decodes x_2

Gain

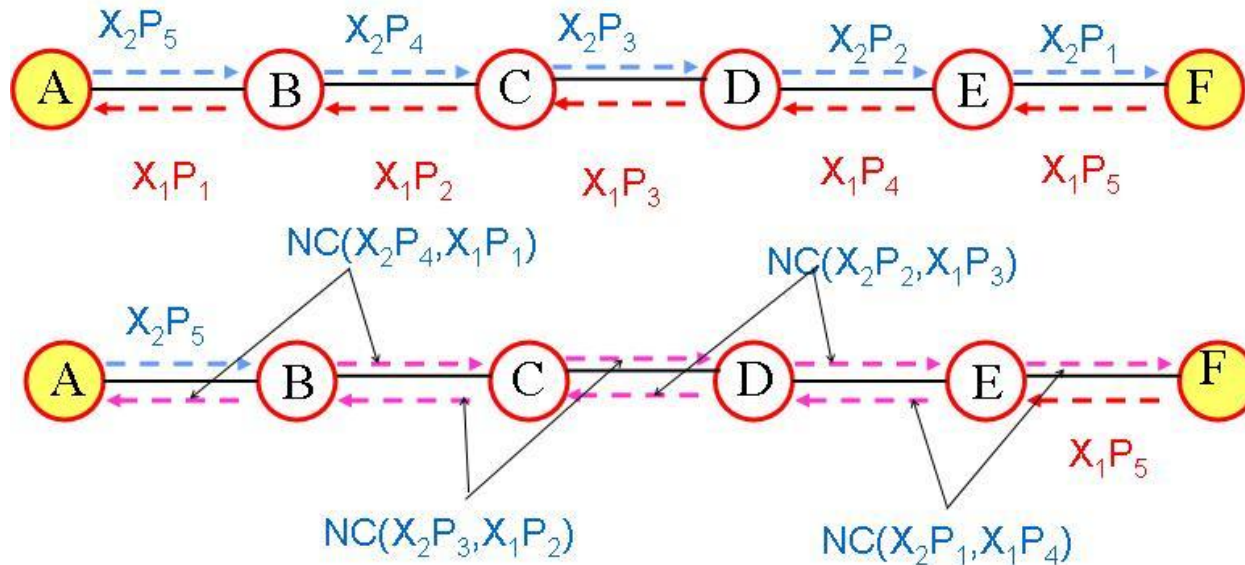
Throughput gain: 33% (from 6 to 4 emissions),

Gain in consumption

Radio resource optimization (nodes C and E)

- Traffic X2 from A to F
- Traffic X1 from F to A
- Linear combination of X1 and X2 packets

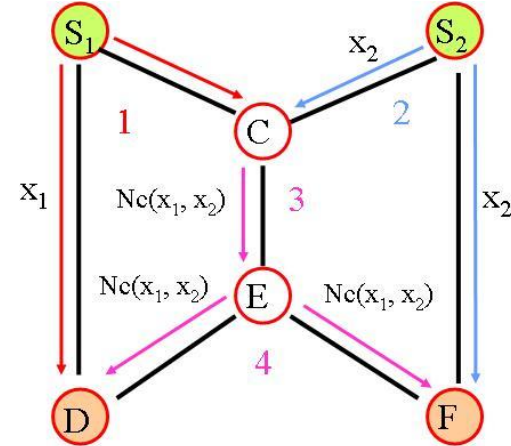
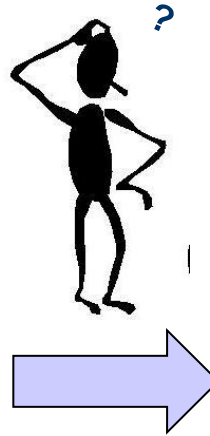
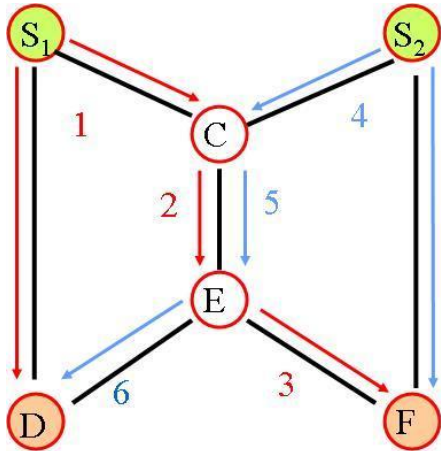
COPE [Katti&all]



Gain

Throughput gain: $(n-2)/2 + 2$, n number of packet emissions

In the example: gain of 40% (from 10 to 6 emissions)



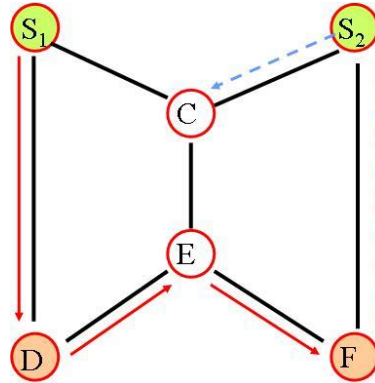
- ◆ Protocol elements proposed to reroute the traffic to optimize the radio resources of a set of independent traffic flows.

Main ideas

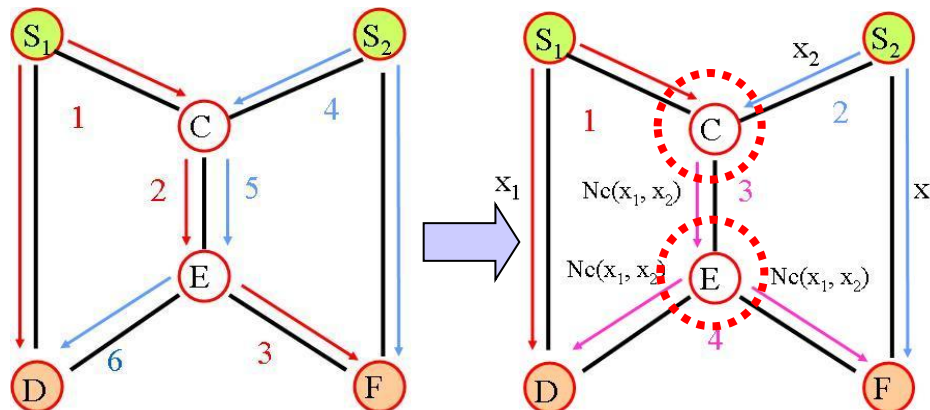
- ◆ **Determination of the topological situation network coding may be applied**
 - Memorization of information on the route flooding phase discovery
 - Transmission of information from the destination nodes to the initial one to detect the optimization potentialities over the network.
 - Minimal multi-traffic routing information reported to the initial nodes to reroute the traffic flows.

Requirements to be met by the solution

- ◆ To be applied on only part time traffic application, some currently on-going.



- ◆ With directives for radio resource allocation optimization



Requirements to be met by the solution

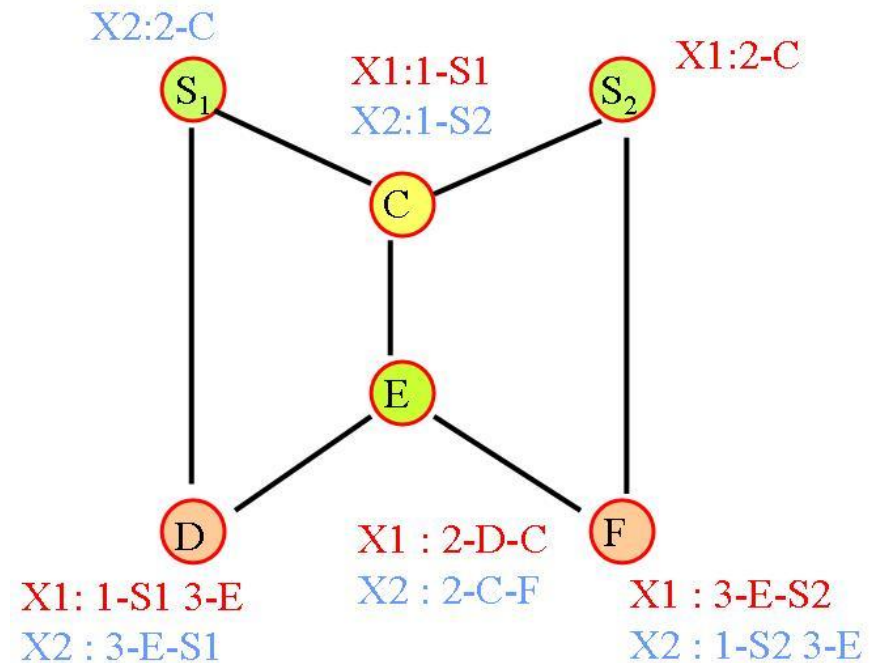
- ◆ Extension to as general as possible topologies, including bi directional flows.
- ◆ Parameterization : NC routing decision to be taken with respect to information (QoS :throughput, latency, link stability, duration of the traffics) collected over the network.
- ◆ To be extended for the use of other kind of multi-flows optimization (cooperative relaying, full use of multi-paths).
- ◆ Capability to switch from “classical” routing to “NC based” routing in identified added-value situation.

First phase:

- ◆ Node memorization information transmitted from the flooding phase using a bounded Dijkstra algorithm [ref Dijk], at a traffic establishment phase.
- ◆ Information memorized at the node step:

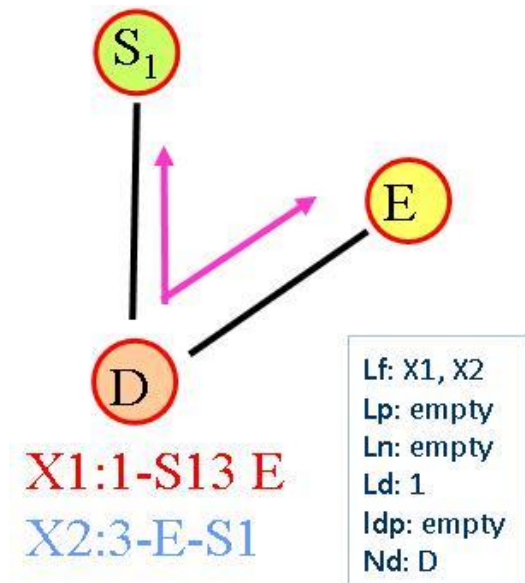
For each flow:

- the distance to the source node, and
- the neighbor identifier
- Time to live memorization time



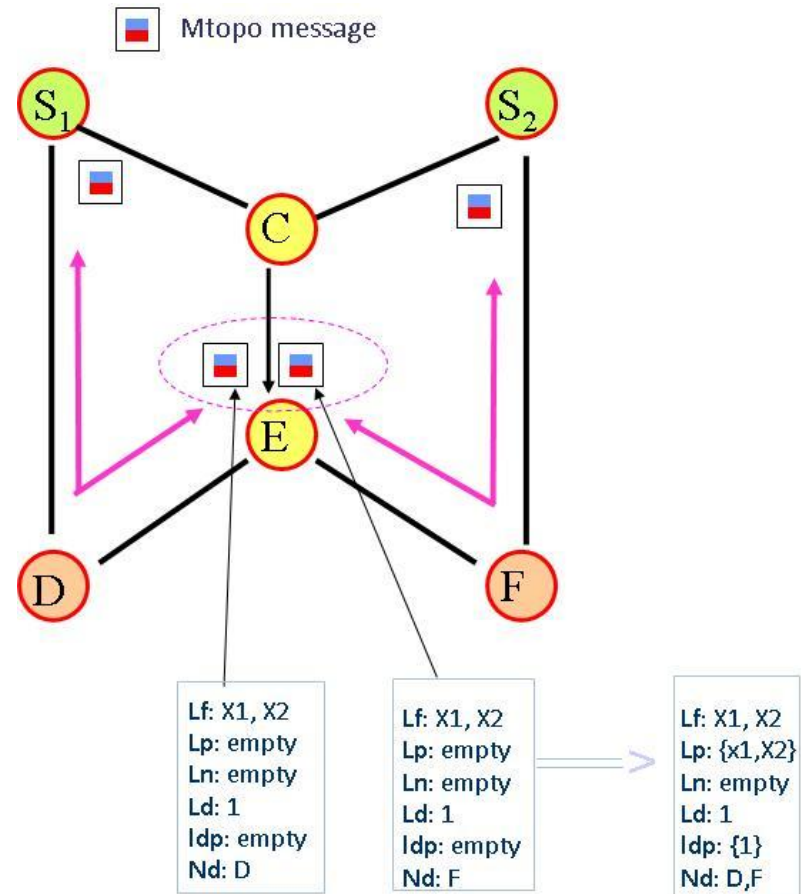
Second phase:

- ◆ Transmission from the destination nodes of MTopo messages to the initial nodes using of the information memorized
- ◆ Main information of the MTopo messages
 - Lf: List of the traffic flows
 - Lp: List of the flows potentially optimized by NC
 - Nd: list of the path distance for the list of flows Lp
 - Ln: list of the traffic flows distance of Lf
 - Nd: list of terminal nodes originator of the message information



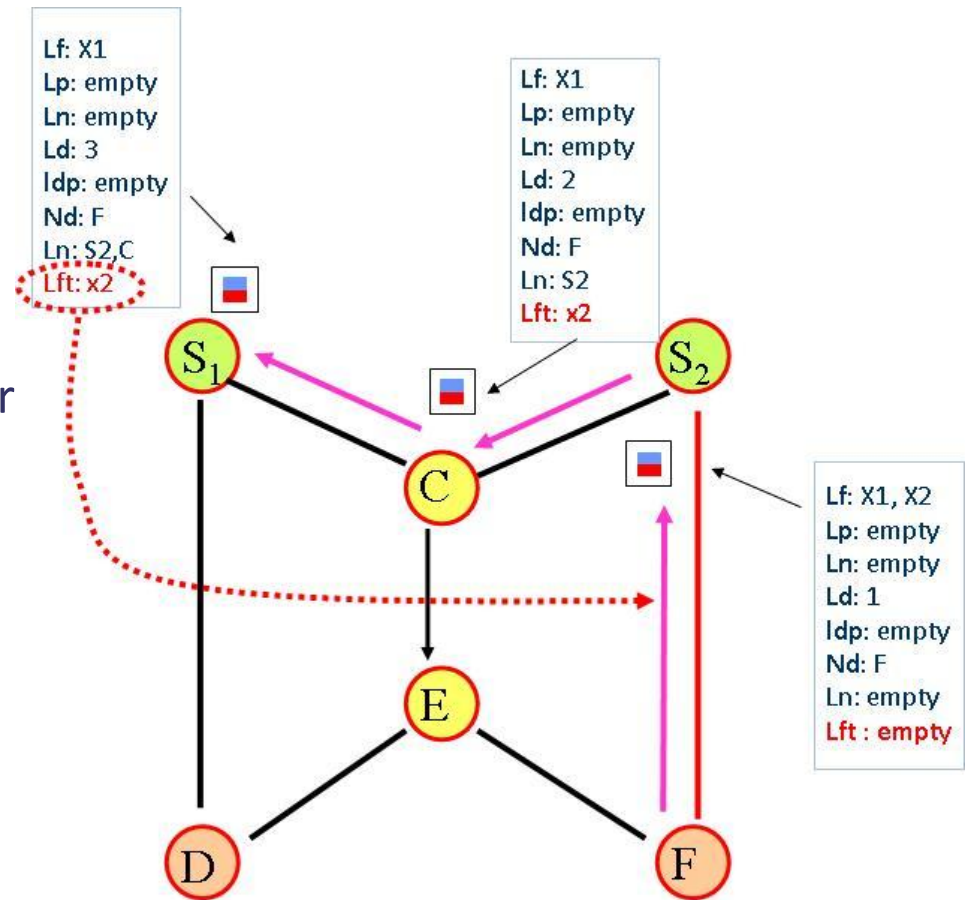
Second phase:

- ◆ Relay node detection
- ◆ From packets received from different neighbors, a node may determine if it can be a potential relay node for the network coding of several flows.
- ◆ In the example, node E is a potential relay node for the flows X1 and X2
- ◆ The Mtopo messages are transmitted to the initial nodes.



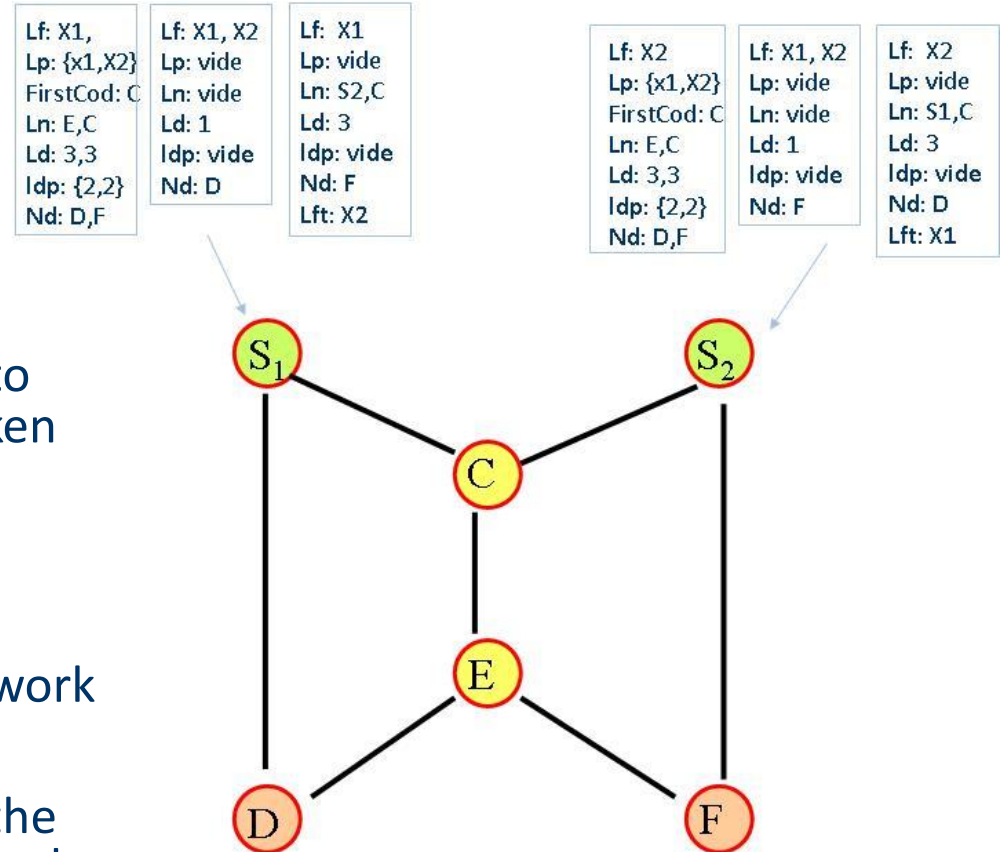
Second phase:

- ◆ The Lft parameter indicates that a path contains a sub path for a flow from a destination node to the initial node of the flow of the list Lft.
- ◆ In the example, S1 has the knowledge of the S2-F traffic link for X2.
- ◆ S1 (resp. S2) knows if S2 (resp.S1) has multipaths to access to final nodes.
- ◆ The S1 and S2 nodes have not to synchronize to decide to apply network coding optimization



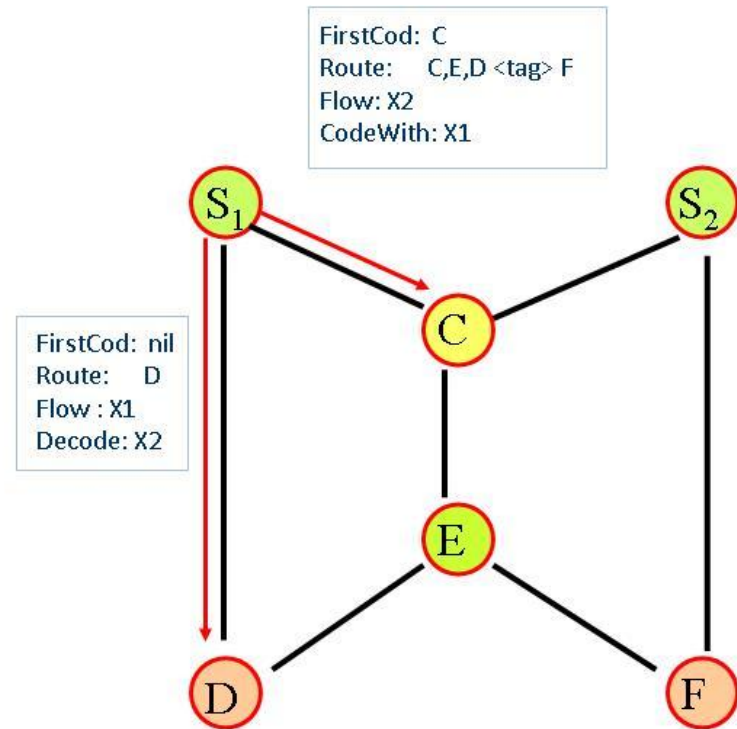
Third phase:

- ◆ From the information relayed to the S1 and S2, decisions are taken on the application of network coding.
- ◆ Complementary information:
 - FirstCod: first node the network coding will be applied
 - Ldp: List of distances from the FirstCod to the destination nodes of the coded traffic



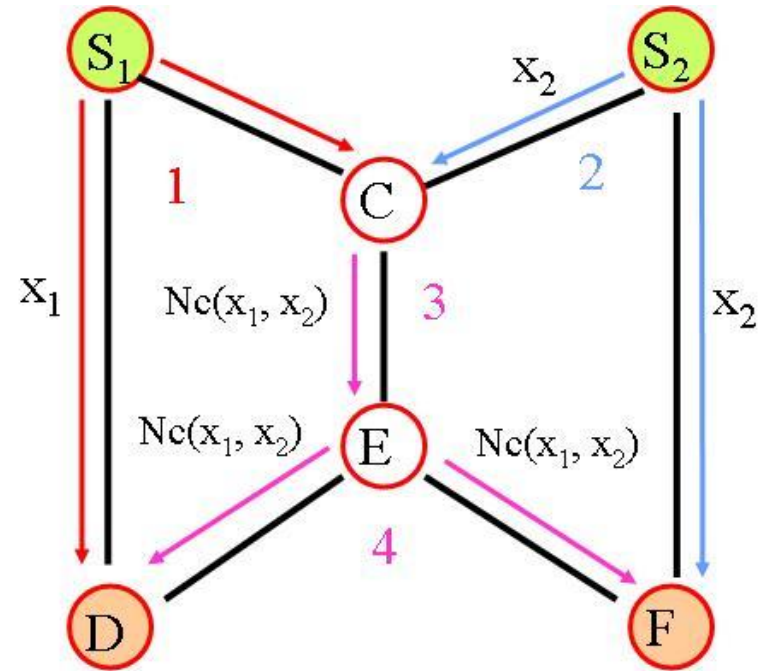
Fourth phase:

- ◆ Determination of the new routes, with potentially use of Network Coding.
- ◆ Transmission of MEstablish messages
 - FirstCod: first node the coding is applied, null if no coding applied
 - Branches the route is broadcast for multicast in a list
 - Flow id of the traffic establishment
 - Flow id of the flow(s) NC is applied



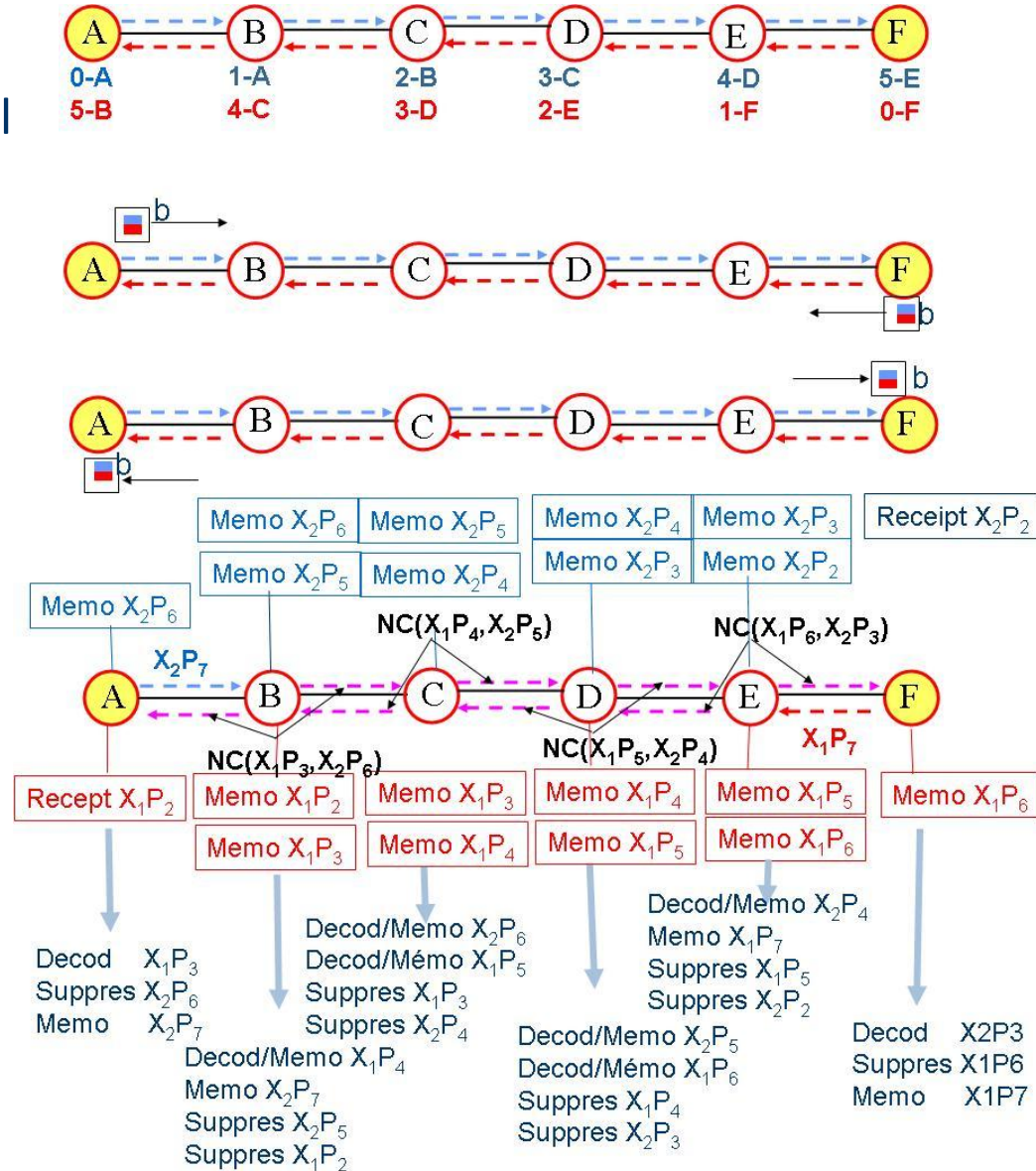
Fifth phase:

- ◆ Establishment of the traffic with the coding/decoding directives applied.



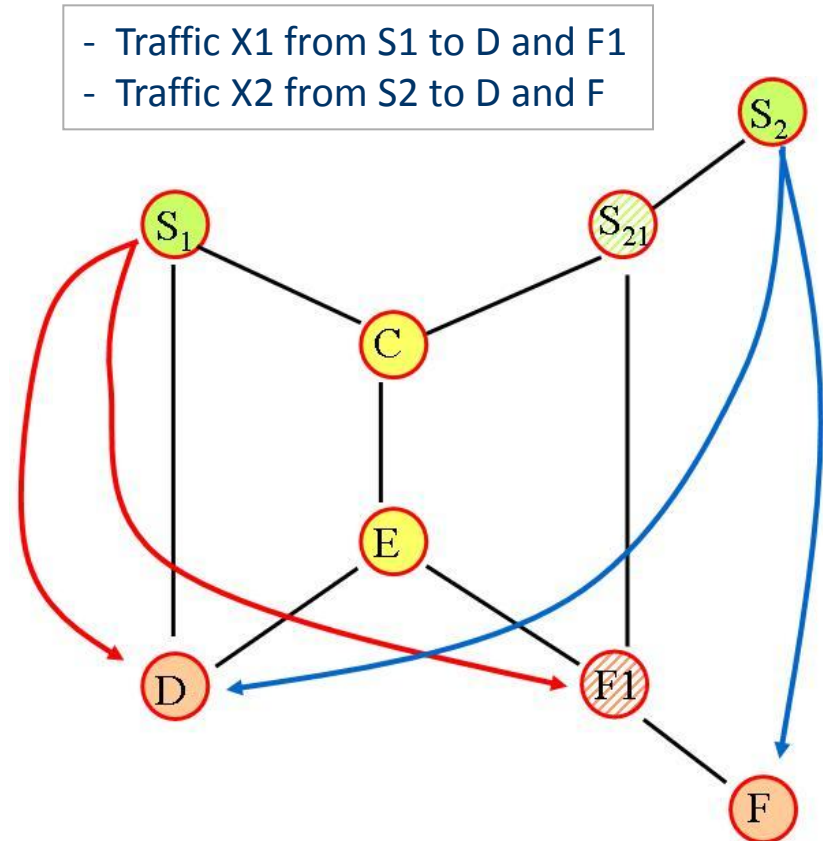
Application on bidirectional flows:

- ◆ Nodes A and F considered as initial and final
- ◆ Field added on Mtopo messages
 - bidirFlows: Info on the flows bidirectional
- ◆ Modification on the algorithm
 - Memorization of packets received
 - Coding/Decoding phases on each relay nodes



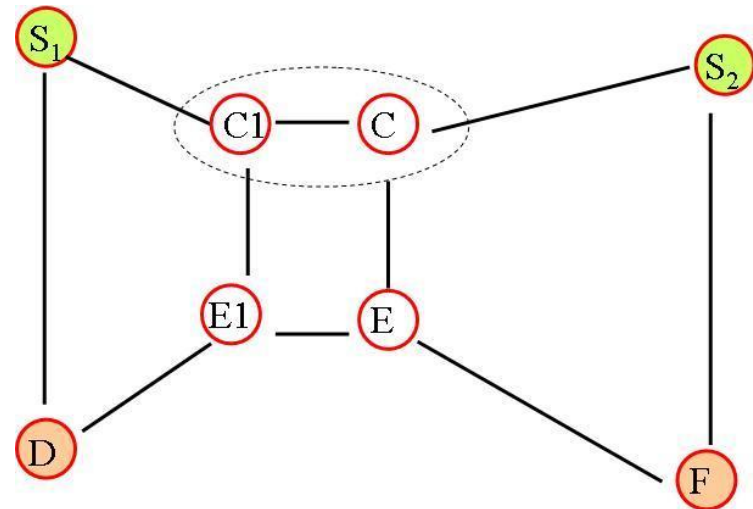
Definition of the delegated nodes

- ◆ Initial delegated nodes:
 - S2 delegates to S21 the Lft information stamping.
- ◆ Destination delegated nodes
 - F delegates to F1 the destination node behavior



Detection of multi paths network coding may be used

- ◆ Deterministic determination of one of the two potentialities
- ◆ Use of the two paths to improve the throughput



Thank you for your attention

[Onefit] www.onefit-eu.org

[ETSI RRS] <http://www.etsi.org/website/technologies/RRS.aspx>

[Yeung&all] R.W. Yeung and Z. Zhang, “Distributed source coding for satellite communications,” *IEEE Trans. Inf. Theory*, pp. 1111–1120, 1999.

[COPE] Katti, S.; Rahul, H. Wenjun Hu Katabi, D. Medard, M. Crowcroft, J “XORs in the Air: Practical Wireless Network Coding” *IEEE/ACM Transactions on Networking*, June 2008
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[Dijkstra] Cormen, Thomas H.; Leiserson, Charles E.; Rivest, Ronald L.; Stein, Clifford (2001). "Section 24.3: Dijkstra's algorithm". *Introduction to Algorithms (Second ed.)*. MIT Press and McGraw-Hill. pp. 595–601.