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

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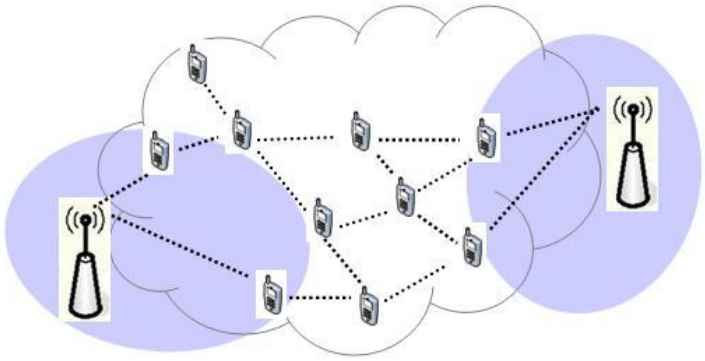
Context, rationale, optimization proposal

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]

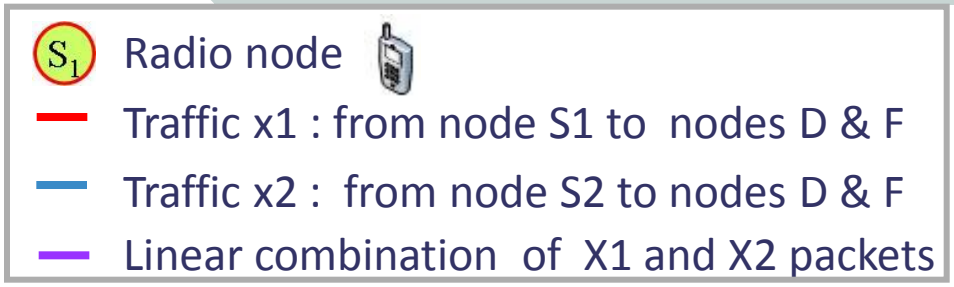


Focus on the optimization on the ad-hoc part of the Opportunistic network.

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

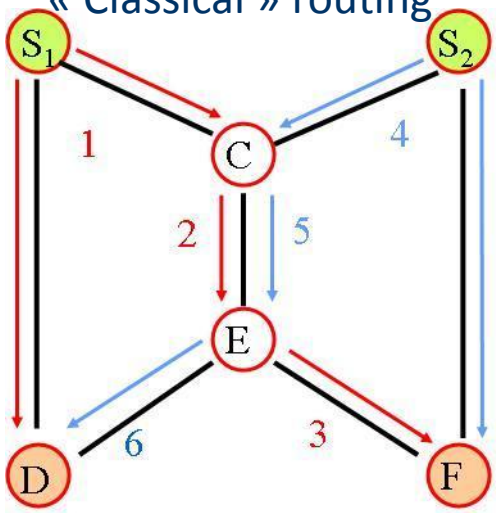
Proposal : Use combination of network coding with routing protocols

Network coding Principle (1/2)

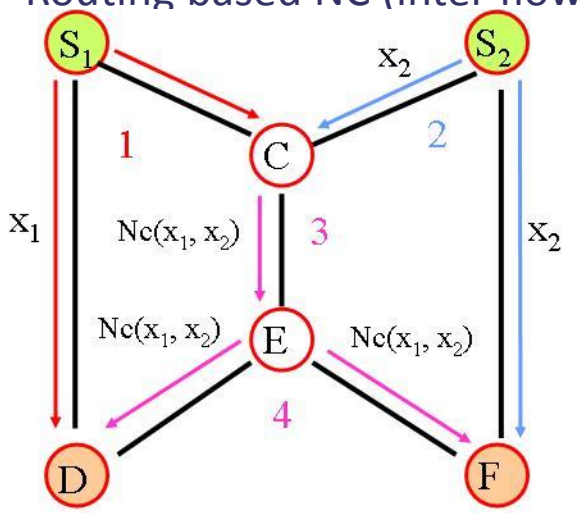


[Yeung&all]

« Classical » routing



Routing based NC (inter flow)



Principle

Nc(x1, x2) = x1 xor x2

Size (Nc(x1, x2)=size(x1)=size(x2)

D receives X1 and, NC(x1,X2), D decodes x2

Gain

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

Gain in consumption

Radio resource optimization (nodes C and E)

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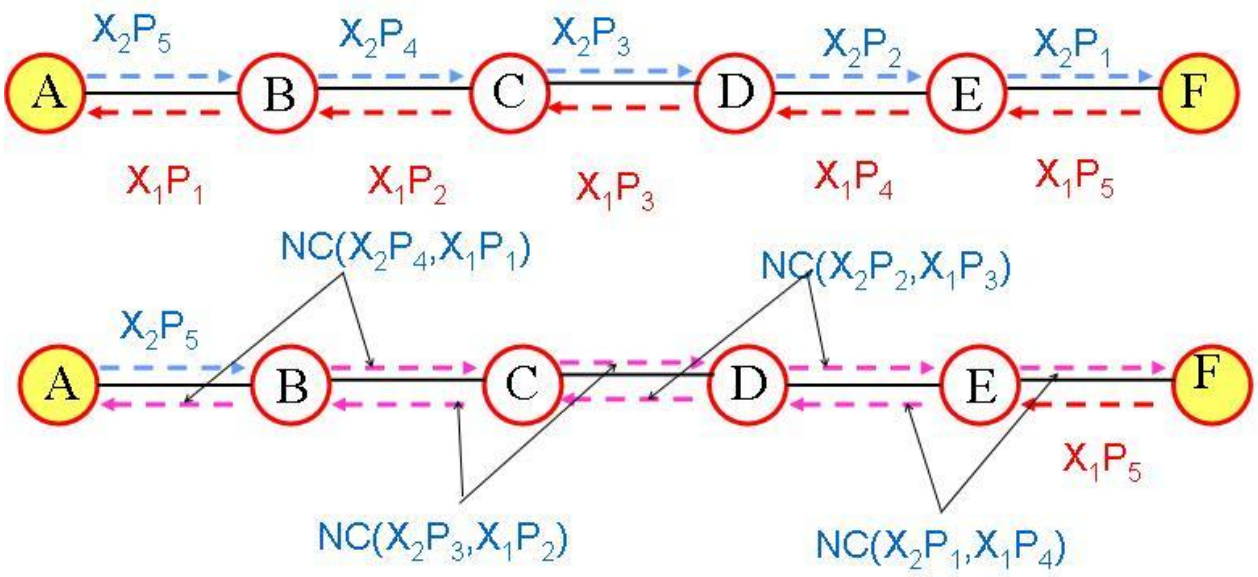
Network coding Principle (2/2)

Traffic X2 from A to F

Traffic X1 from F to A

Linear combination of X1 and X2 packets

COPE [Katti&all]

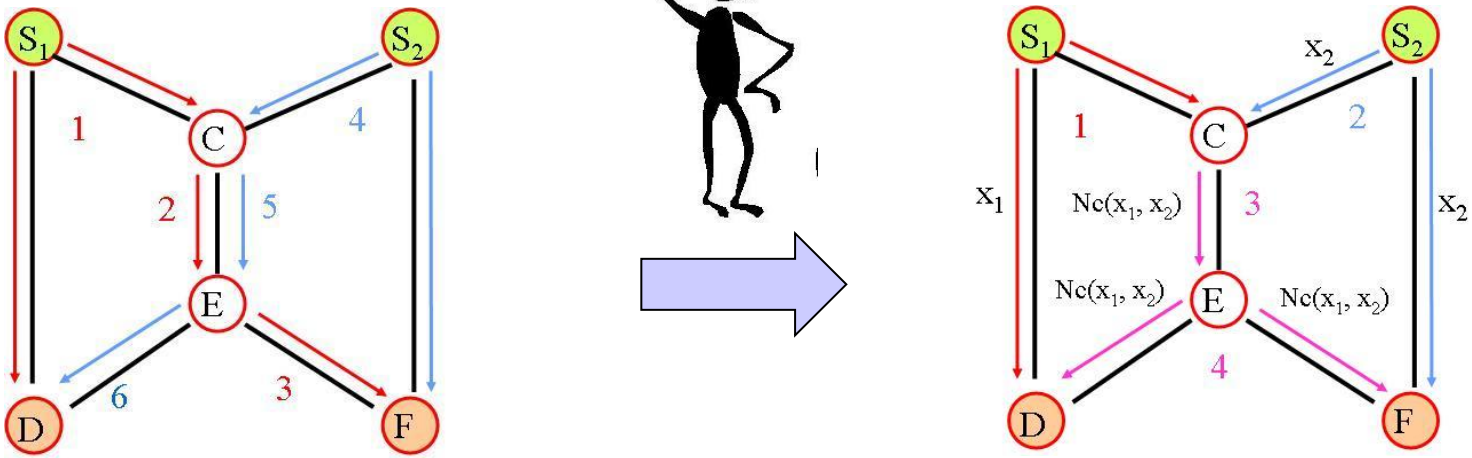


Gain

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

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

Rationale on the example



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

Algorithm: Main idea

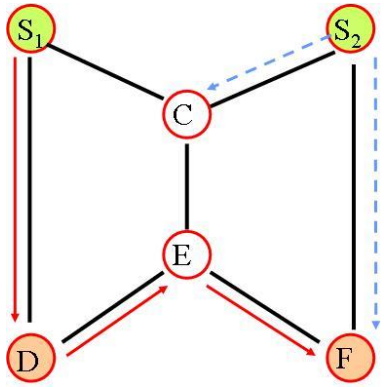
Main ideas

- **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.

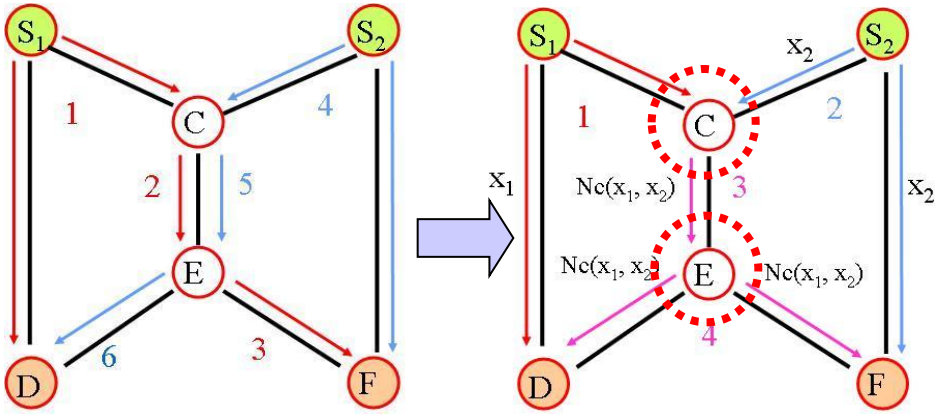
Requirements expected on the solution

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**



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Requirements expected on the solution

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.**

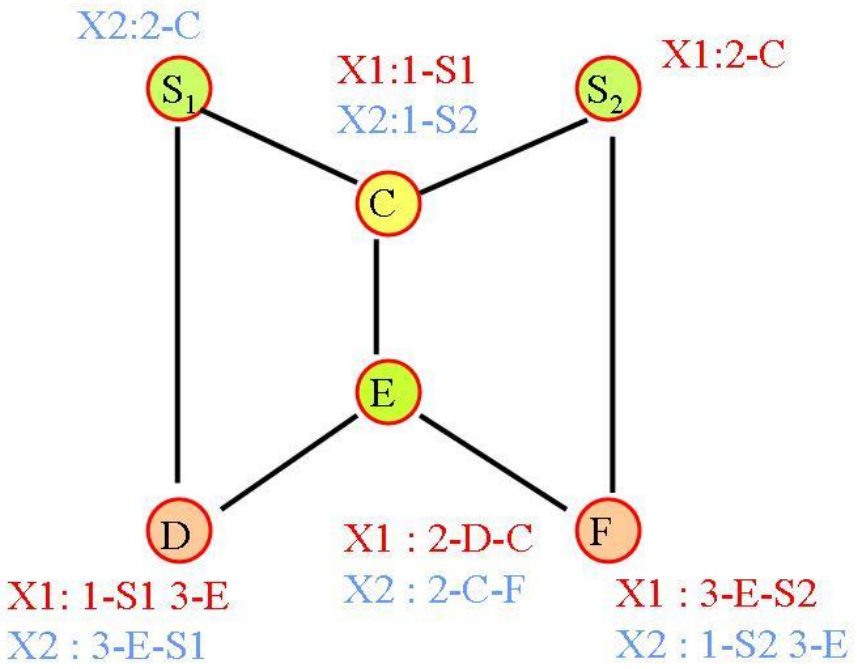
Algorithm description: First phase

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:

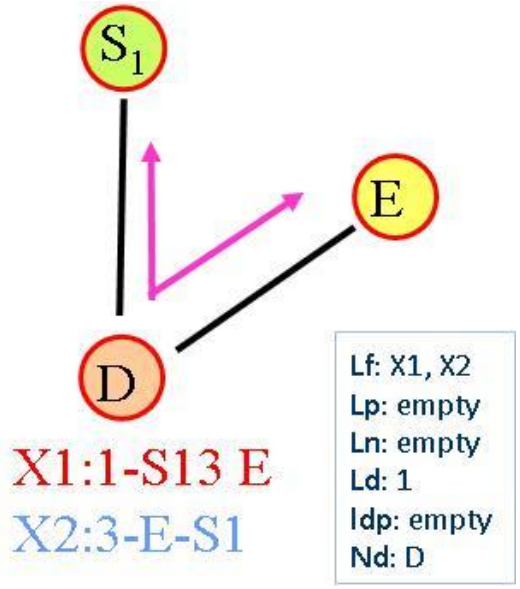
  - the distance to the source node, and
  - the neighbor identifier
  - Time to live memorization time



Algorithm description: Second phase

Second phase:

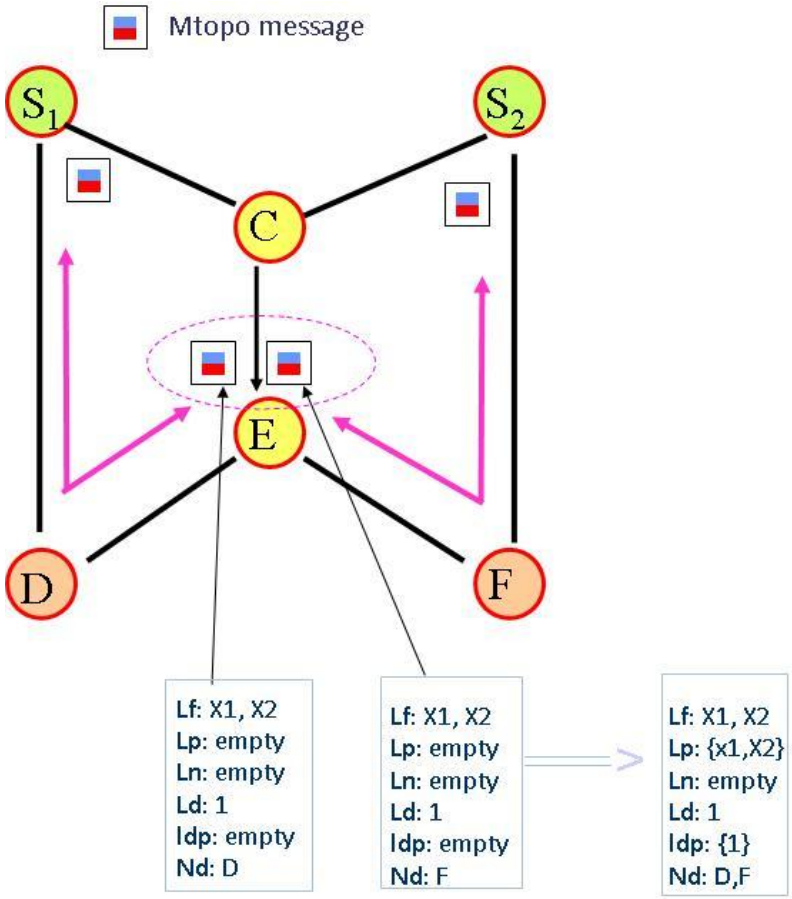
- Transmission from the destination nodes of MTopo messages to the initial nodes using of the information memorized
- Main information of the MTopo messages
  - **Lf: List of the traffic flows**
  - **Lp: List of the flows potentially optimized by NC**
  - **Nd: list of the path distance for the list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



Algorithm description: Second phase

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.



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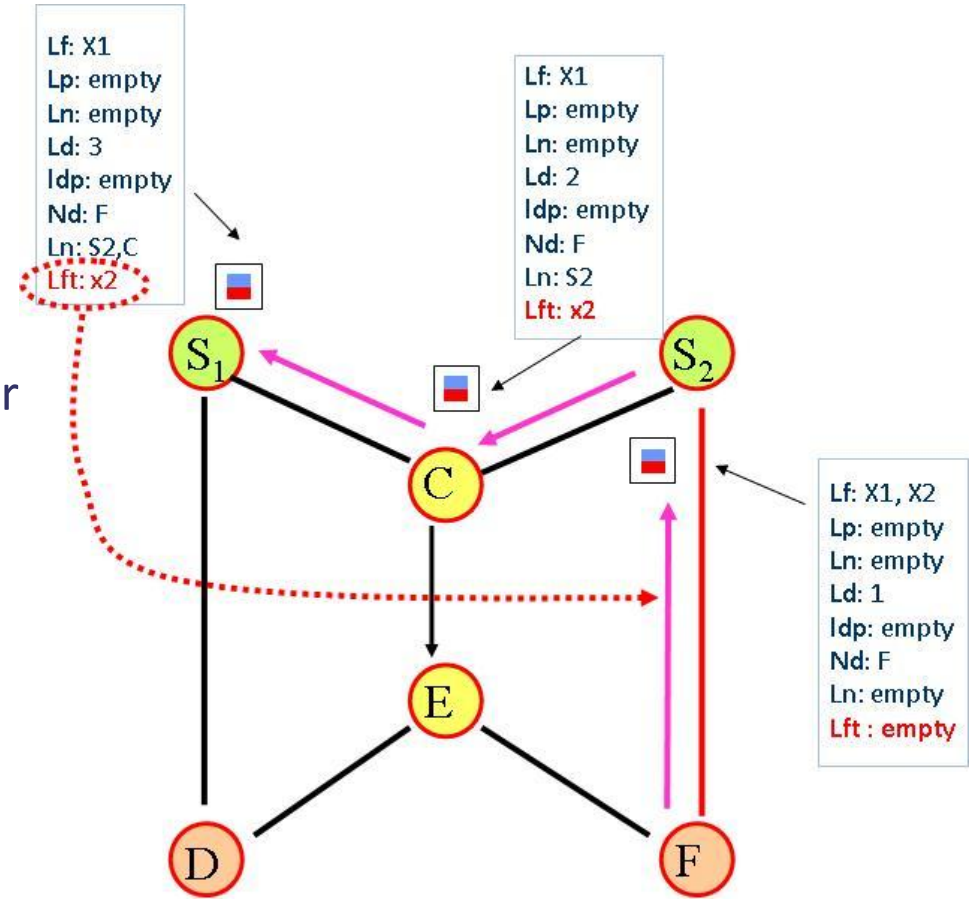
Knowledge of other flow paths at a flow initial node

Second phase:

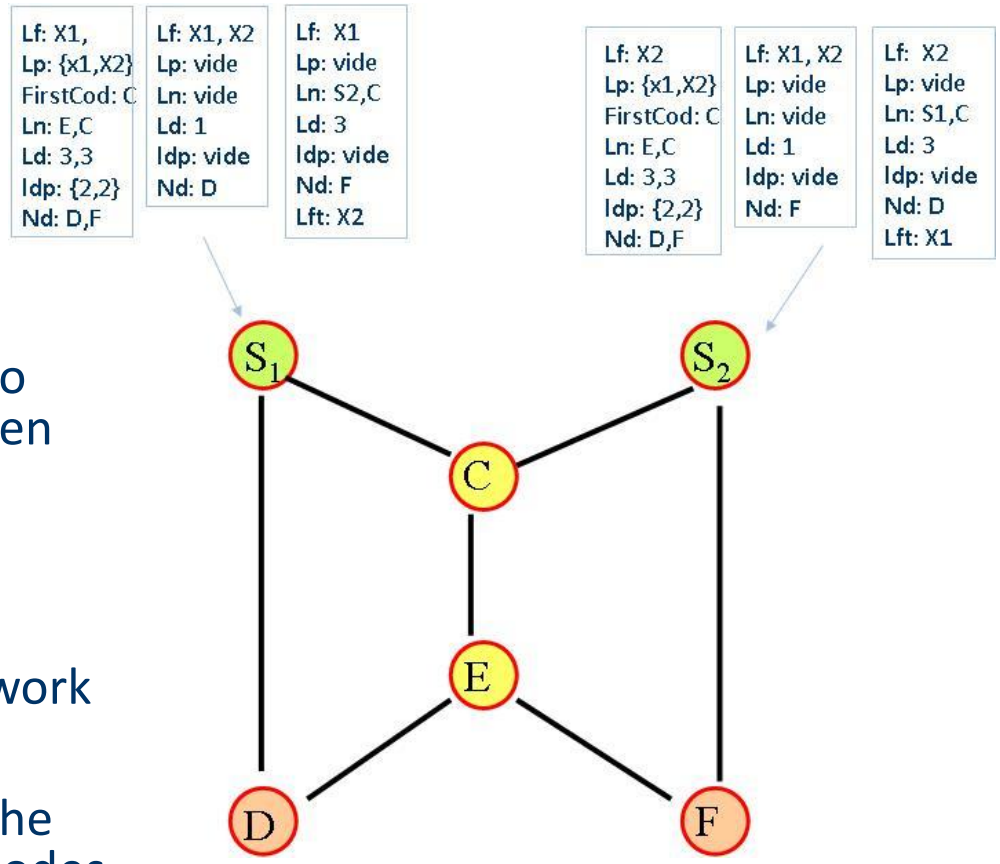
- The Lft parameter indicates that a path contains a sub path for a flow from a destination node to the initial node of the flow of the list Lft.
- In the example, S1 has the knowledge of the S2-F traffic link for X2.
- S1 (resp. S2) knows if S2 (resp.S1) has multipaths to access to final nodes.
- The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



Algorithm description: Third phase

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 FistCod to the destination nodes of the coded traffic



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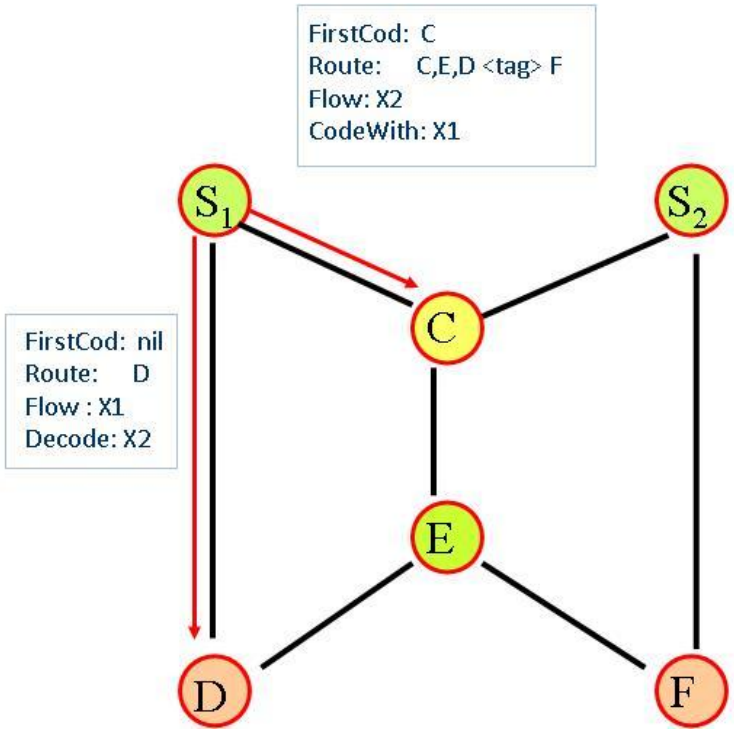
Algorithm description: Fourth phase

Fourth phase:

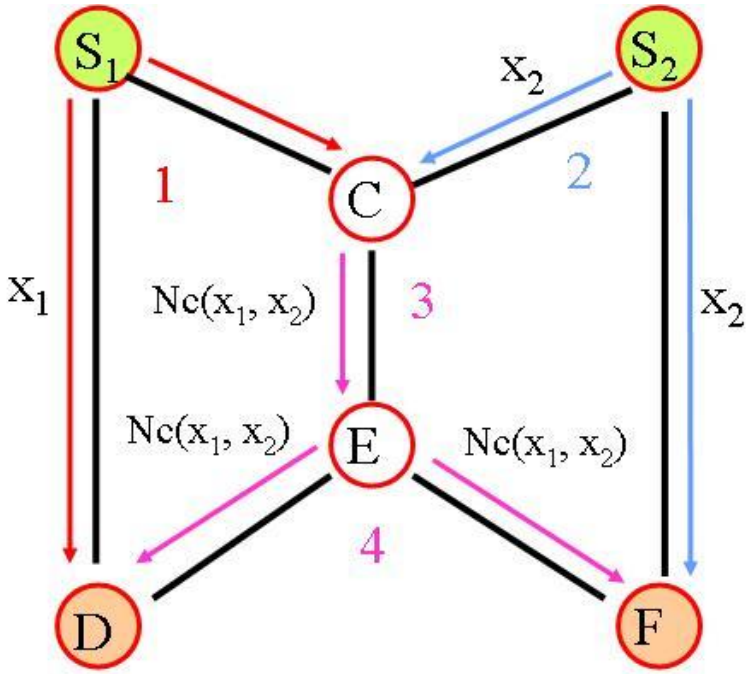
- Determination of the new routes, with potentially use of Network Coding.
- Transmission of MEstablish messages
  - FirstCod: first node the coding is applied, null if no coding applied
  - Branches the route is broadcast for multicast in a list
  - Flow id of the traffic establishment
  - Flow id of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



Algorithm description: Fifth phase

Fifth phase:

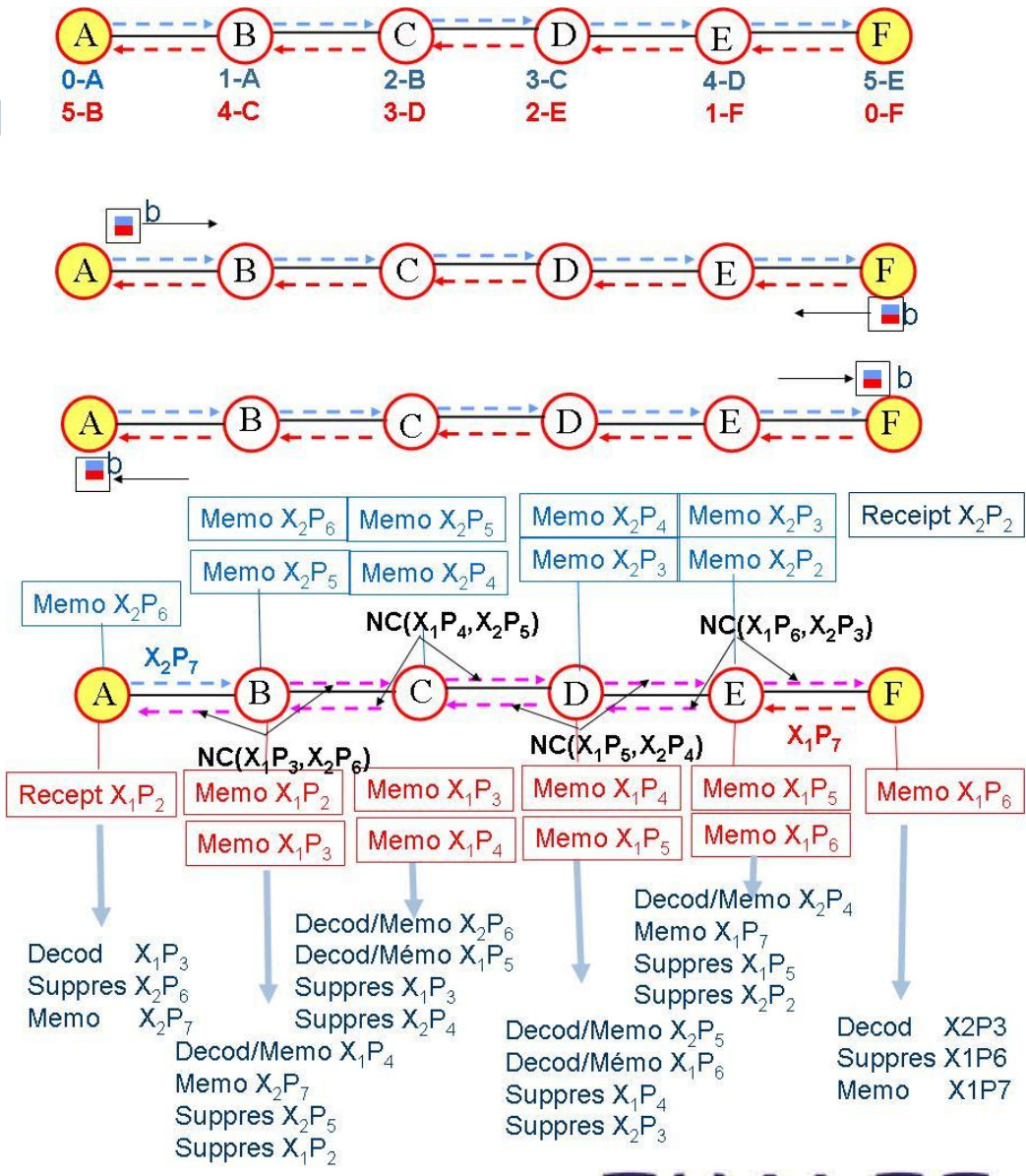
- Establishment of the traffic with the coding/decoding directives applied.



Application on the particular situation of bidirectional flows

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



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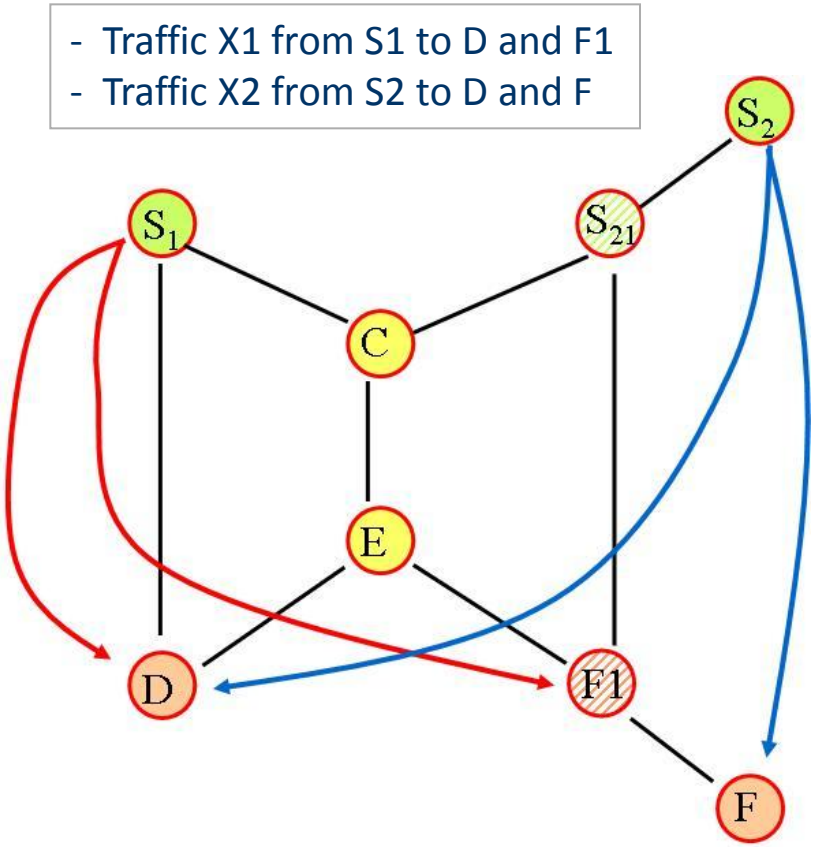
Topologies generalization

Definition of the delegated nodes

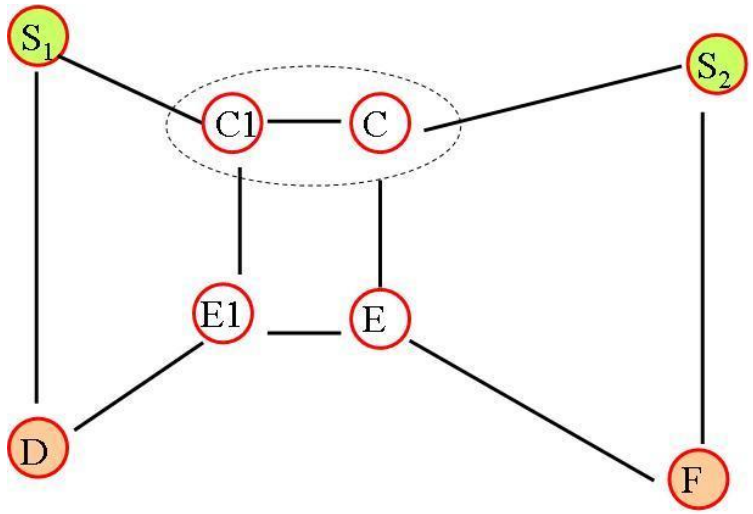
- Initial delegated nodes:
  - S2 delegates to S21 the Lft information stampering.
- Destination delegated nodes
  - F delegates to F1 the destination node behavior



Multi-paths optimization

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



References

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 Volume: 16 Issue:3 On page(s): 497 - 510 ISSN: 1063-6692

[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.