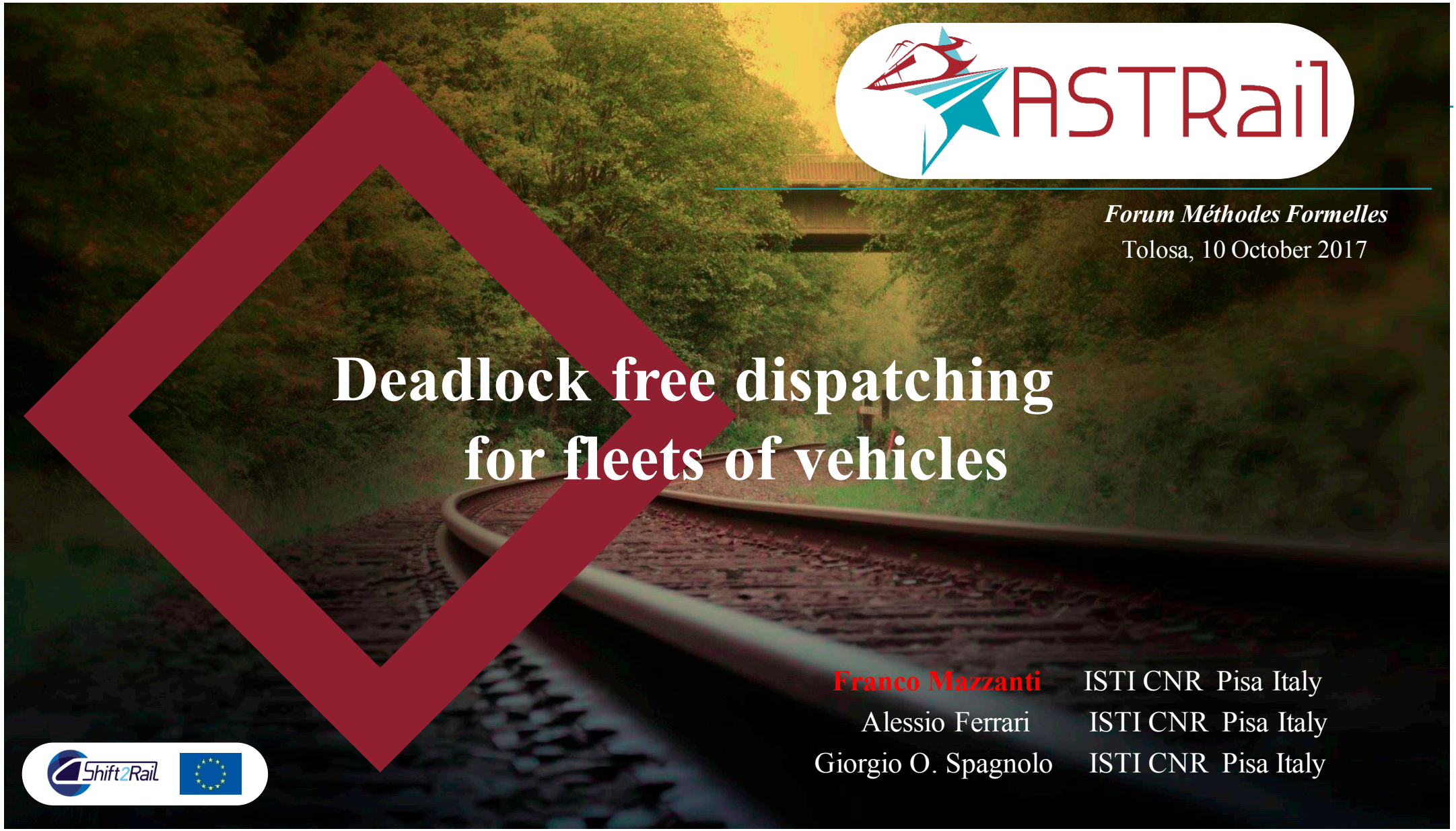

Forum Méthodes Formelles
Tolosa, 10 October 2017

Deadlock free dispatching for fleets of vehicles

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Presentation

CONSIGLIO NAZIONALE DELLE RICERCHE

ISTITUTO DI SCIENZA E TECNOLOGIE DELL'INFORMAZIONE "A. FAEDO"

FORMAL METHODS && TOOLS LABORATORY

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KandISTI 2017 - Open Access

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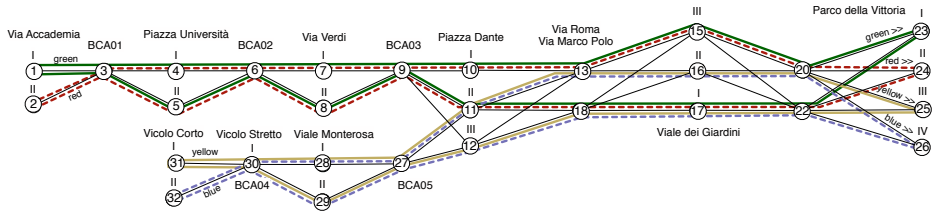
TraCE - IT

Train **C**ontrol **E**nhancement via **I**nformation **T**echnology



The original TRACE-IT goal:

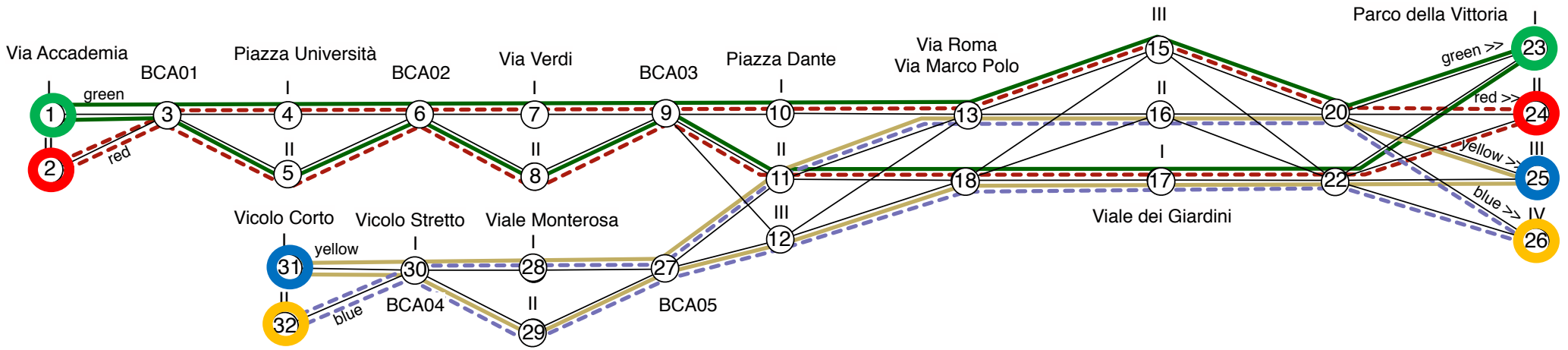
Design an ATS (Automatic Train Supervision) System that:

- Controls the dispatching of a set trains on a railway layout
- Handling a continuously running set of circular train missions
- Preventing the occurrence of (partial) deadlocks.

Safety of the system is guaranteed by the ATP / Interlocking systems

What we have here is essentially a problem of (mission critical) liveness

The original case study



- We have a metro service: 8 trains providing circular services


[1,3,4,6,7,9,10,13,15,20,23,22,17,18,11,9,8,6,5,3,1]



[2,3,4,6,7,9,10,13,15,20,24,22,17,18,11,9,8,6,5,3,2]

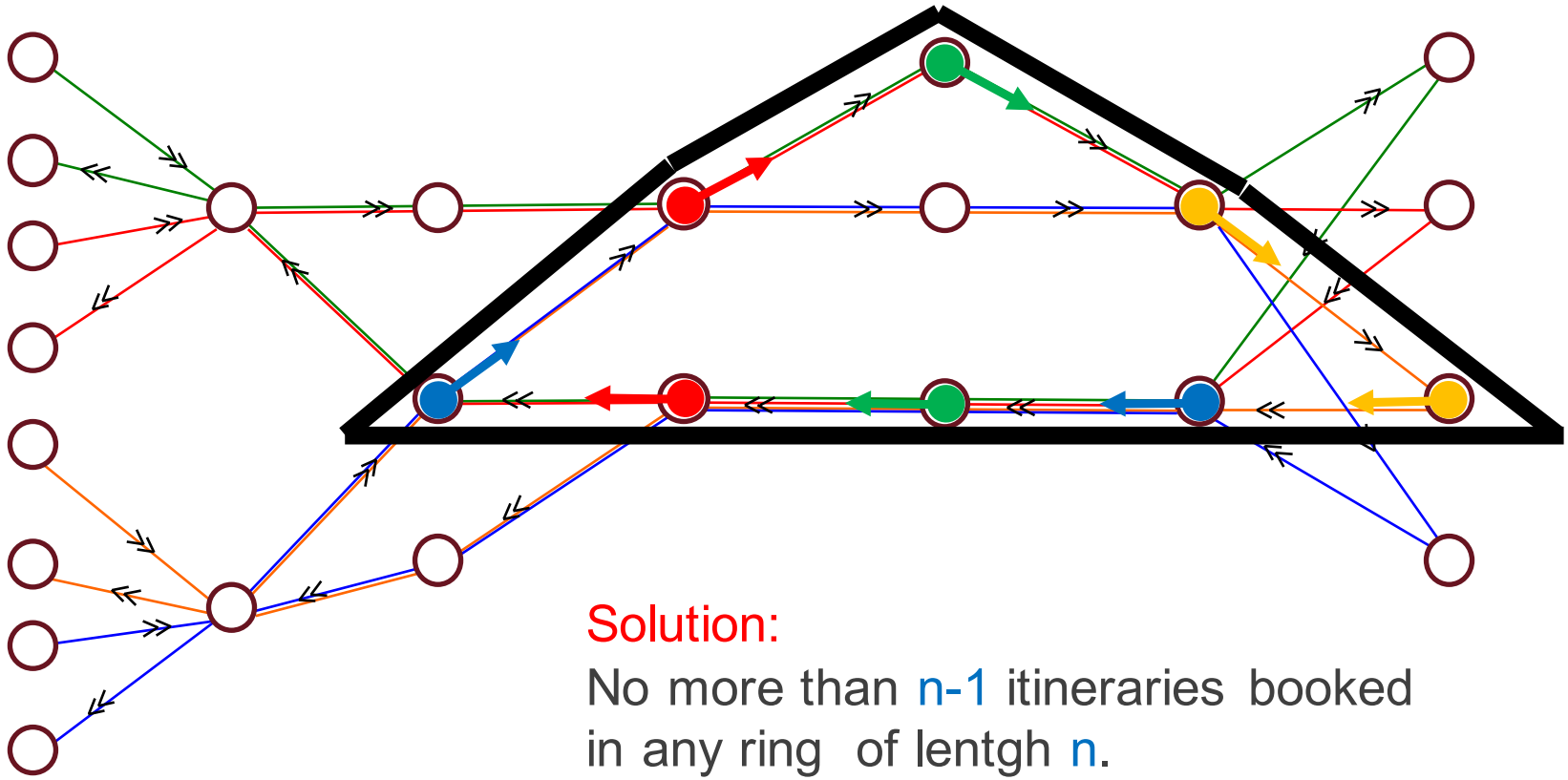


[31,30,28,27,11,13,15,20,25,22,17,18,12,27,29,30,31]



[32,30,28,27,11,13,15,20,26,22,17,18,12,27,29,30,32]

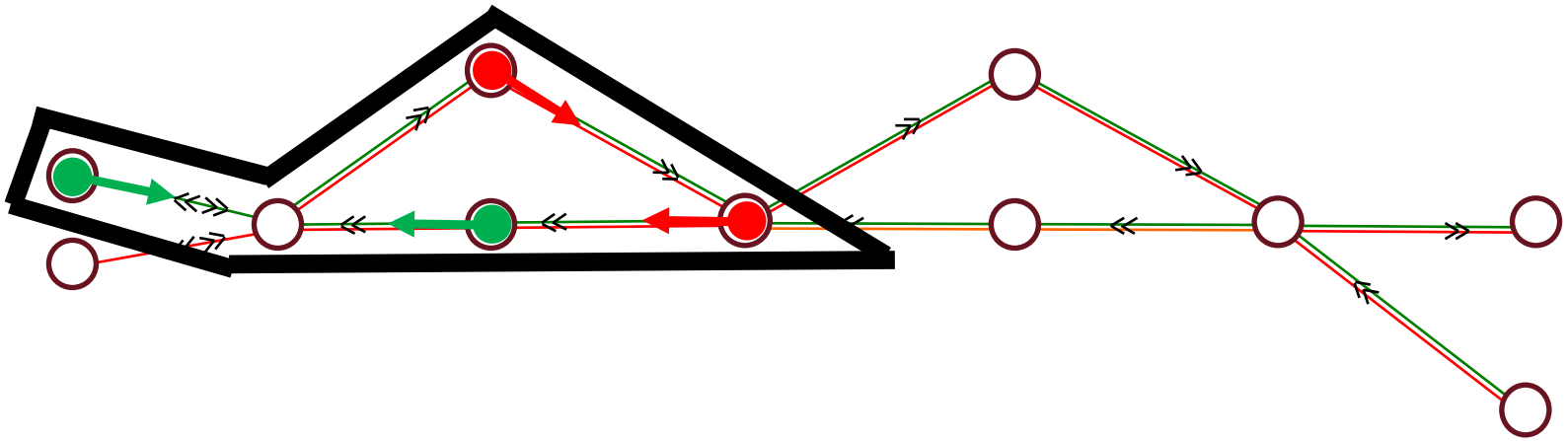

Deadlock on basic sections



Solution:

No more than n-1 itineraries booked in any ring of lentgh n.

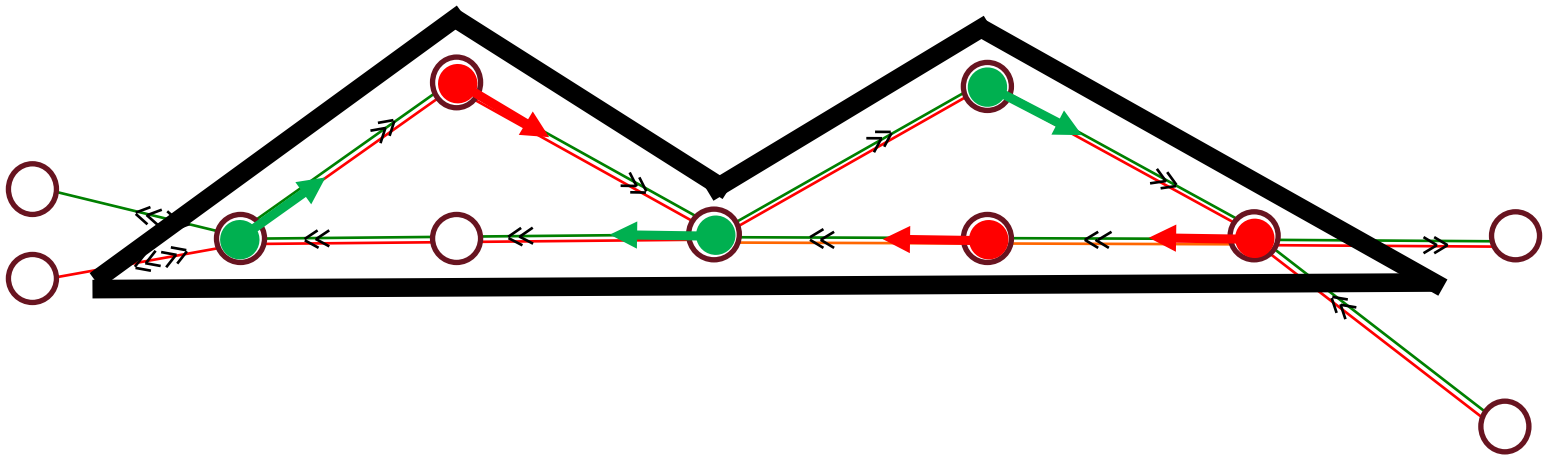
Deadlock on composite sections I



Solution:

No more than 3 itineraries booked inside this section of size 5.

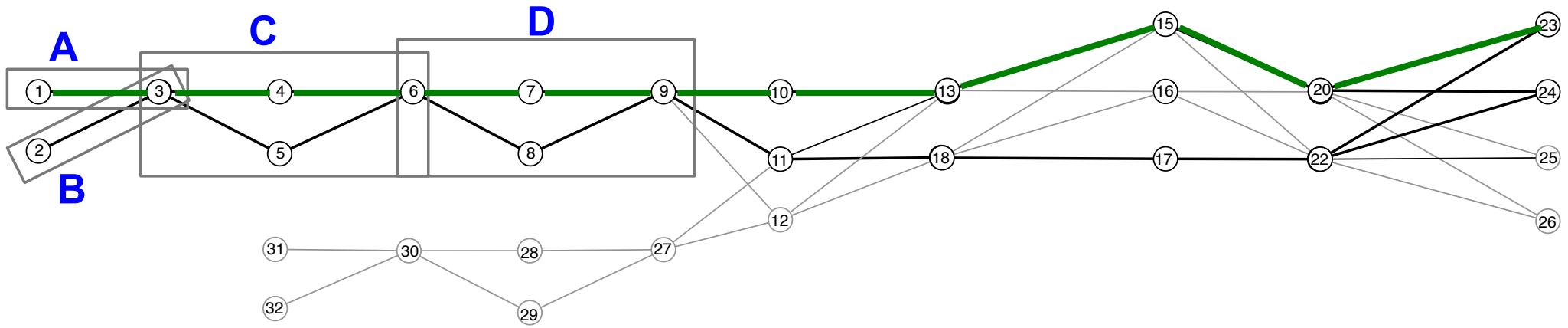
Deadlock on composite sections II



Solution:

No more than 5 itineraries booked inside this section of size 8

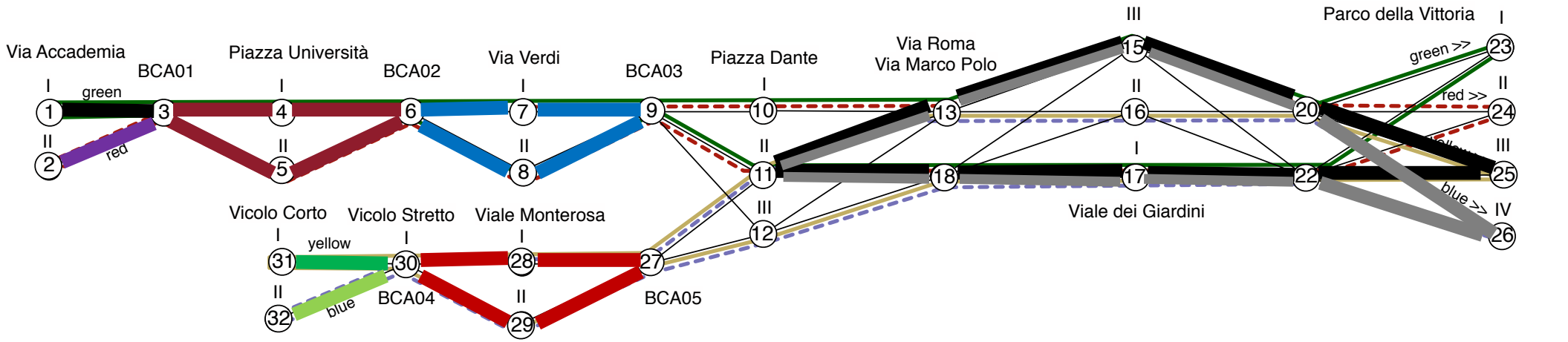
Extended missions



[1 ,3, 4, 6, 7, 9, 10, 13, 15, 20 ,23, . . .]

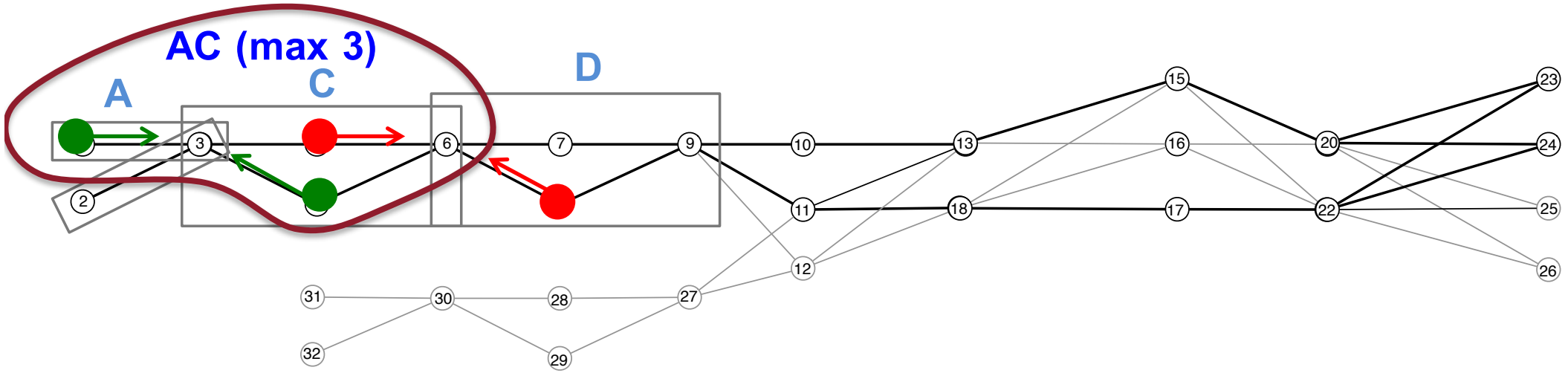
[*(A++;AC++)* 1, *([C<4];A--;C++)* 3, 4, *([D<4];C--;AC--;D++)* 6, 7, *(D--)* 9, . . .]

Discovering basic critical sections



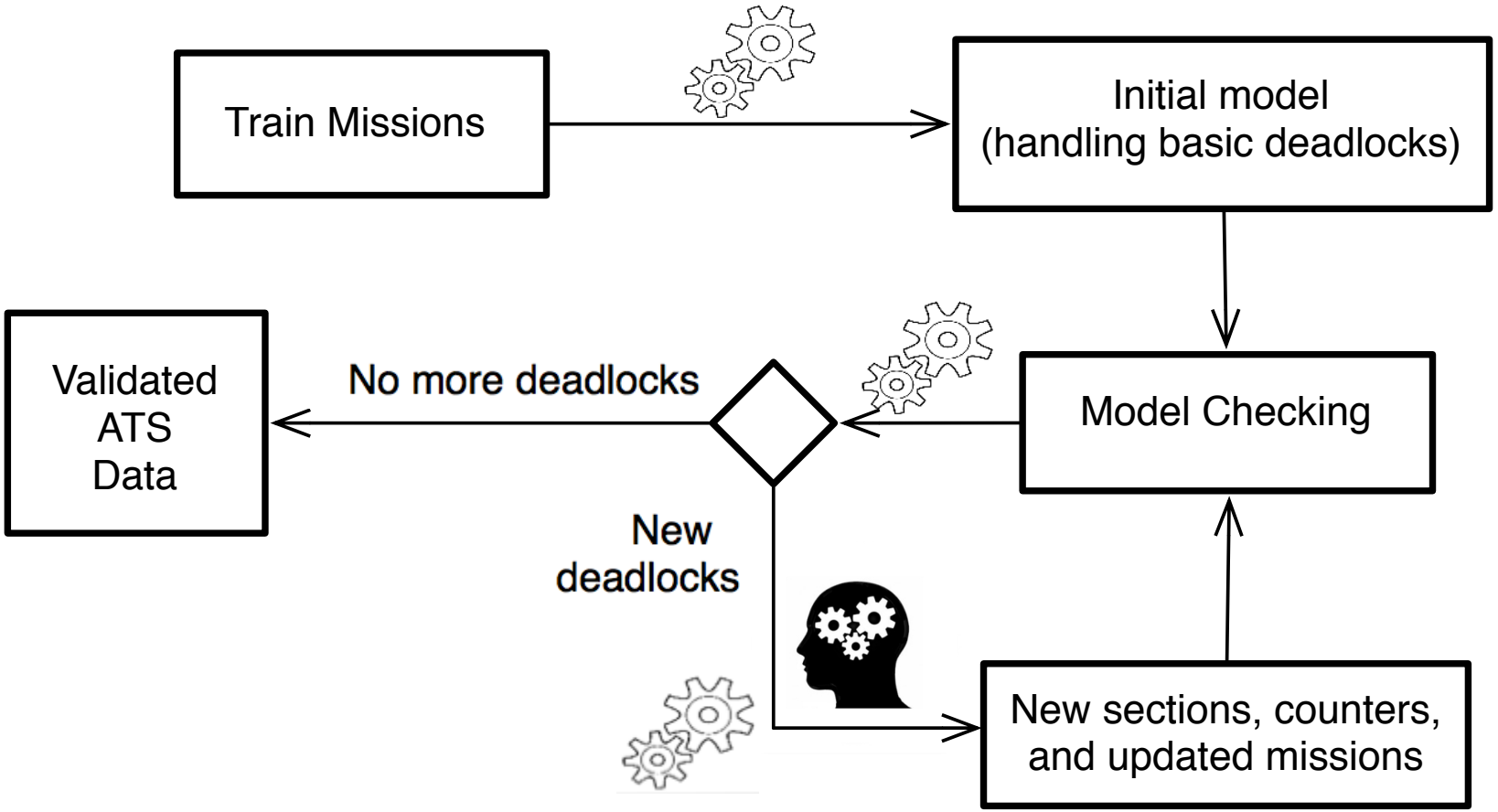
Basic critical sections (rings, bidirectional segments) can be discovered by an analysis of the possible missions.

Discovering composite critical sections



We build a **formal model** of the system and use **model checking** techniques to find **all** situations of deadlock in the composite sections.

The role of model checking

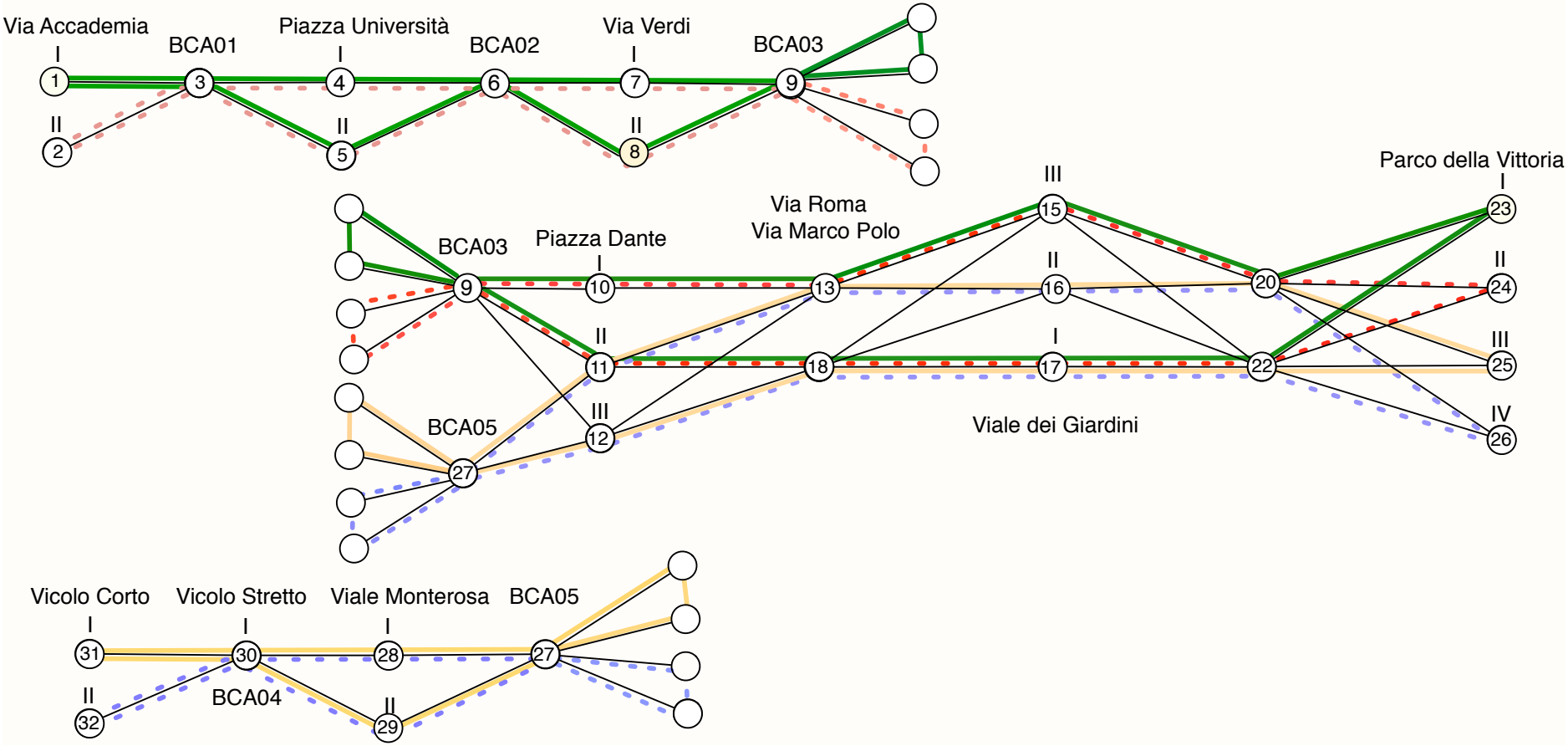


The role of model checking

In the TRACE-IT case study ATS data validation is done statically at configuration / reconfiguration time.

We have also experimented a dynamic automatic approach using a custom ad hoc model checker.

System Decomposition



References

More details on the approach to deadlock avoidance:

Mazzanti, F., Spagnolo, G.O., Della Longa, S., Ferrari, A.

Deadlock avoidance in train scheduling: A model checking approach

9th International Conference on Formal Methods for Industrial Critical Systems, FMICS 2014;
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Mazzanti, F., Ferrari, A., Spagnolo, G.O.

Experiments in Formal Modelling of a Deadlock Avoidance Algorithm for a CBTC System

T. Margaria and B. Steffen (Eds) ISoLA 2016, Part II
Lecture Notes in Computer Science - Volume 9953, 2016


ASTRail
SAtellite-based Signalling and Automation SysTems
on Railways along with Formal Method and Moving Block validation
THANK YOU!
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