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Advanced MOVA Group Linking on Distributed Controllers

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Introduction

Traditional linking between MOVA controllers uses pulses and holds sent between the MOVA streams to force the streams to stay in sync with each other. We have been exploring the difficulties and shortfalls with this type of MOVA linking and proposing new ways of ensuring important junction streams stay in sync while running MOVA.

This paper is an overview of the projects which included a new way of linking MOVA controllers, MOVA group linking on distributed controllers. This includes the use of an orchestrating controller sending group messages to slaves in the network where the decisions on stages can be made based on the group running. This ensures that all controllers in the linked network are in sync all of the time while still maintaining the safety and adaptability of MOVA control.

MOVA linking has traditionally been problematic for achieving variable offsets between stop lines, this paper also looks at how the group link theory can be used to change the offset and maximise capacity through the network.

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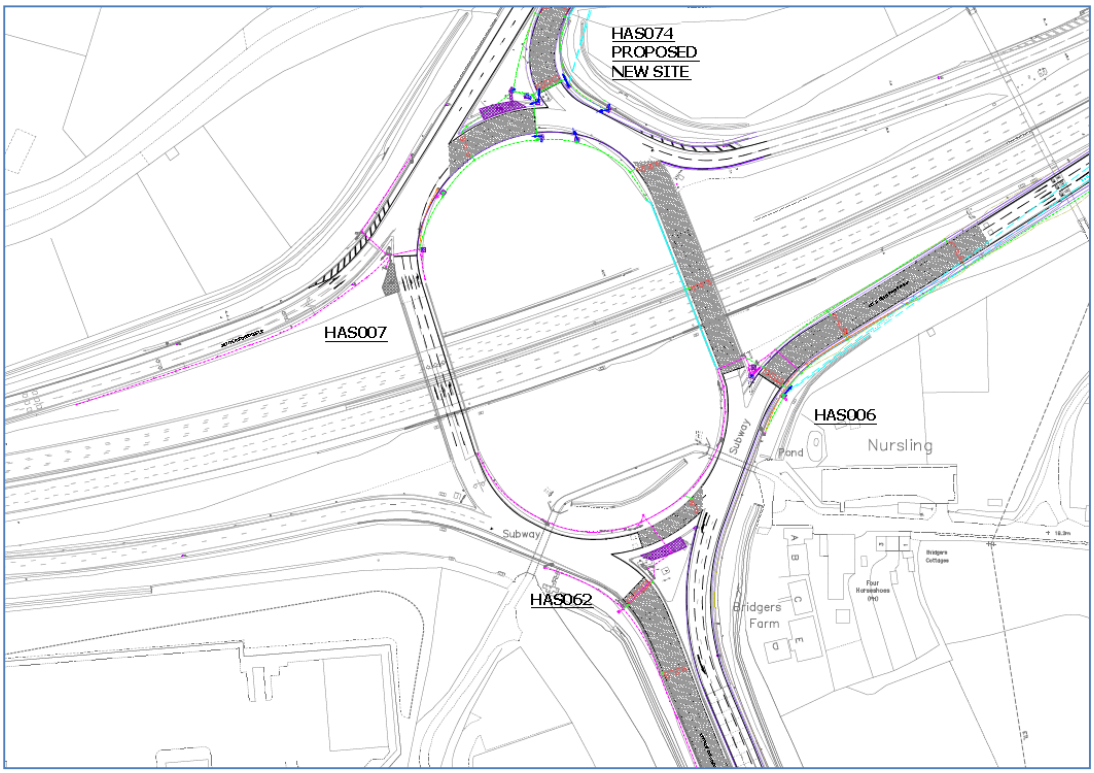
Case Study

M27 J3, M271, Southampton, Hampshire.

The intersection in question is a roundabout above the M27 which has four entrances and exits, two are slip roads for the M27 with the other two being the M271 Northbound from Southampton and the M271 Southbound from Romsey.

Each of the approaches to the roundabout are controlled by a separate Traffic Controller and MOVA unit with linking cables between them; all four of these streams must work together to prevent gridlock on the circulatory.



There are three main flows through the intersection during the peak period:

1. M271 Northbound to M27 Eastbound – At all times, with the evening peak experiencing the highest flows
2. M27 Eastbound to M271 Southbound – Extremely high flows in the morning peak with moderate flows in the evening peak.
3. M27 Westbound to M271 Southbound – At all times, with the highest flows in the morning peak.

All of the above movements conflict with another of the three, this means that without linking between all four controllers the gyratory very quickly becomes gridlocked.

Group Linking

The concept behind group linking is to attempt to combine distributed MOVA controllers into a type of multimode while still maintaining the option to split these controllers back into stand alone streams.

To ensure that the controllers remain in sync one of the controllers is used as the orchestrating object which chooses the group for the intersection to run in and passes this to the Group Actuator script in each controller.

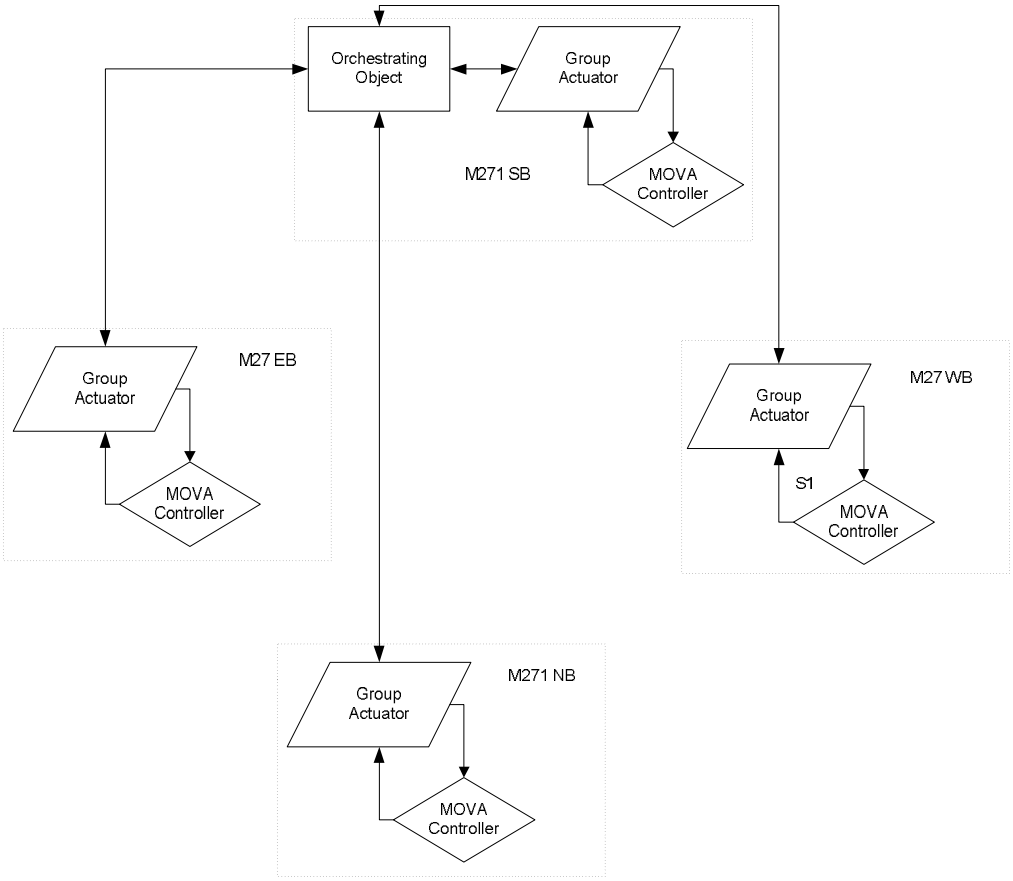


Figure 1 Example of Group Linked Controllers

The group actuator script in each controller is programmed to put actions onto its associated MOVA controller dependant on the group selected; returning messages to the Orchestrating Object which may be required to make decisions.

These return messages are usually End of Stage, End of Saturation Flow on link(s), queue loop outputs or oversaturation flags.

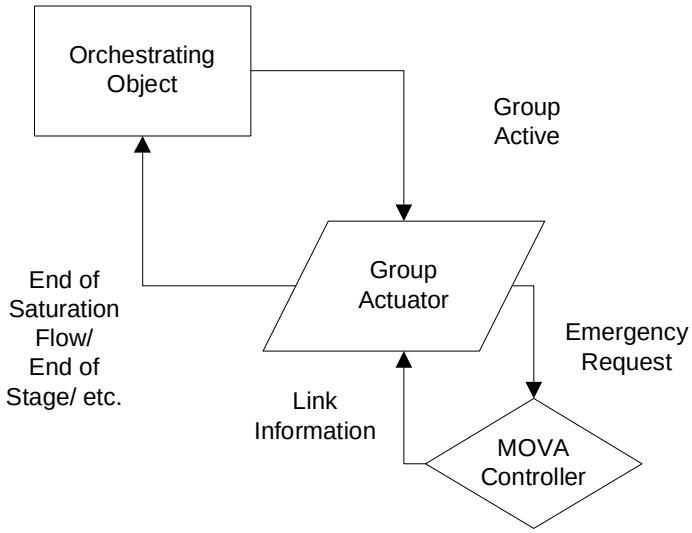


Figure 2 Relationship between Orchestrating Object, Group Actuator and MOVA Controller

Actions during groups need to be decided for each actuator to enable the four controllers in the group to act as if only one stream is being used:

Controller	Action	Group 1	Group 2	Group 3
M271 SB	1st Action	S1 Force	S1 Held	S2 Force
	2nd Action	S1 Held	S1 Held	Release*
M27 EB	1st Action	S2 Force	S2 Held (Queue dependant timer)	Release (Timed) Hold S2 on change
	2nd Action	S2 Held	S1 Force	S2 Held
M271 NB	1st Action	S2 Force (Timed)	S1 Held	S1 Held (Queue dependant timer)
	2nd Action	Release*	S1 Held	S2 Force
M27 WB	1st Action	S2 Hold	Release (S2 Force after Timer)	S1 Held (Queue dependant timer)
	2nd Action	S2 Hold	Release*	S2 Force

*Released controllers in red force an action in the Orchestrating Object

The Orchestrating Object needs to make decisions on the change of group, this is done when a released MOVA controller reports End of Saturation Flow on a relevant link (dependant on Oversaturation Flags or Queue detectors active) or ends the current stage.

	Action to End Group	Move To Group
Group 1	M271 NB Stage 2 Ends	2
Group 2	M27 WB Stage 2 Ends/ End of Sat Flow	3
Group 3	M271 SB Stage 2 Ends/ End of Sat Flow	1

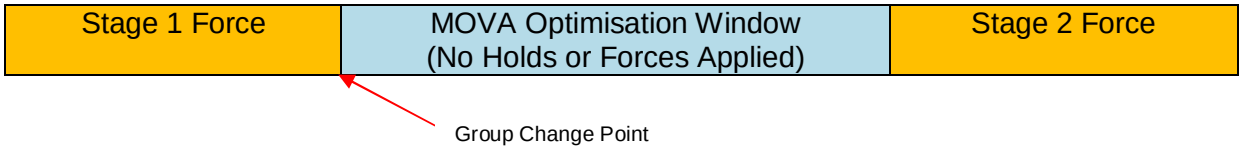
The Orchestrating Controller is now effectively in control of several streams ensuring that the cycle times are matched and the traffic entering the gyratory from the main approaches does not create a rolling queue/ is blocked.

Minimum and maximum timers are created for every group and set of decisions to ensure that the controller does not get stuck in a group under fault conditions.

Off Peak Relaxation of Linking

During peak periods group linking requires immediate action at the forced change points to allow the best use of green time throughout the intersection. This obviously means that the advantages of finding gaps in the MOVA model is often lost when the decision to move stage occurs (much like when the MOVA controller is in oversaturation mode).

During off peak periods during the day however this strict movement is less important and therefore can be relaxed. Instead of instantly forcing a change of stage the hold bit from the group actuator to the MOVA Controller can be removed and the new force bit applied after a timed window:



The use of the MOVA Optimisation Window allows the local MOVA controller to find gaps to safely change before moving to the next stage.

At night however when there is no need for linking, all of the linking is switched off.

Offset Control Between Streams

Linked MOVA sites traditionally use a set offset between the streams to allow progression through the linked MOVA region. This works OK but can often cause rolling queues and less effective green time when a released platoon is stopped at the back of a queue which has not yet discharged.

With the Group Linked MOVA concept this can be mitigated with extra messages between the Group Actuators controlling the release timers for specific stages. Using the information from the X, IN and Q loops at the downstream controller, the release timer in a group can be changed to different times allowing the efficient release of the platoon.

As an example here is the timer selection for the M271 NB controller during Group 3:

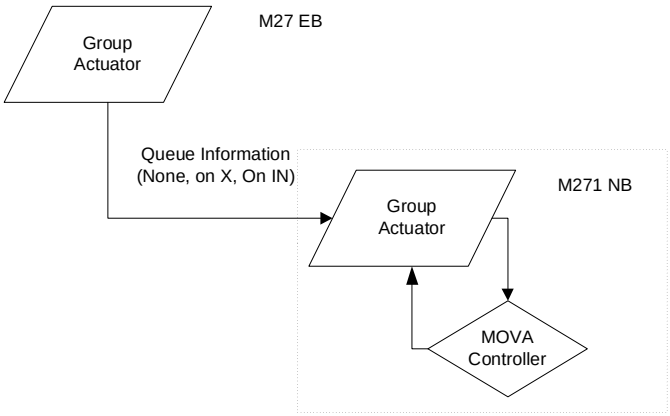


Figure 3 Queue Information Sharing M27 EB to M271 NB

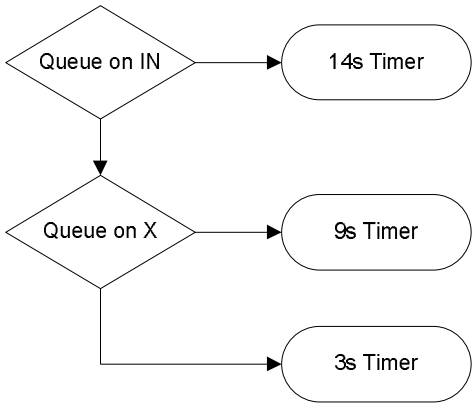


Figure 4 M271 NB Timer Selection Logic in Group Actuator

The timer selection above depicts how soon after the start of Group 3 stage 2 is forced on the M271 NB MOVA controller, this allows a semi-changeable offset between the two stop lines dependant on the length of the queue between them.

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Summary

Linking multiple MOVA streams using a single orchestrating controller allows for much more accurate synchronisation across the linked region as a whole; allowing for improved offset control between stop lines.

One of the main issues with traditional MOVA linking, where priority/ emergency requests are sent between two controllers, is the possibility of the two controllers getting out of sync. This is a problem experienced on many linked junctions observed and usually happens when insufficient traffic is arriving at the junction at the end of a peak, “flip flopping” between stages can often be seen when the requests are sent in both directions. With a more advanced system using the orchestrating object to tell all streams the current group, this problem has been mitigated.

The use of group linking has many advantages when it comes to decision making across multiple controllers; instead of each MOVA controller deciding when to change stage, the decisions are based on data across all streams, viewing the region as a whole.

Strategies can also be applied to the model allowing the orchestrating controller to make different decisions based on queue detection and Oversaturation Flags, allowing the system to be more adaptive than traditional simple MOVA linking. Actions include (but not limited to):

- Changing offset timers
- Removing/ Reducing MOVA Optimisation Windows
- Changing Min/ Max Timers for Groups
- Changing 1st – 2nd Action timers/ decision points in groups
- Allowing Extra Groups (clearance strategies)
- Forcing Dataset Selection on some/ all MOVA Controllers

The strategies are all controlled locally removing the reliance on communication infrastructure.

MOVA Group Linking is an innovative but powerful tool that can be applied to multiple stream intersections and distributed controllers.