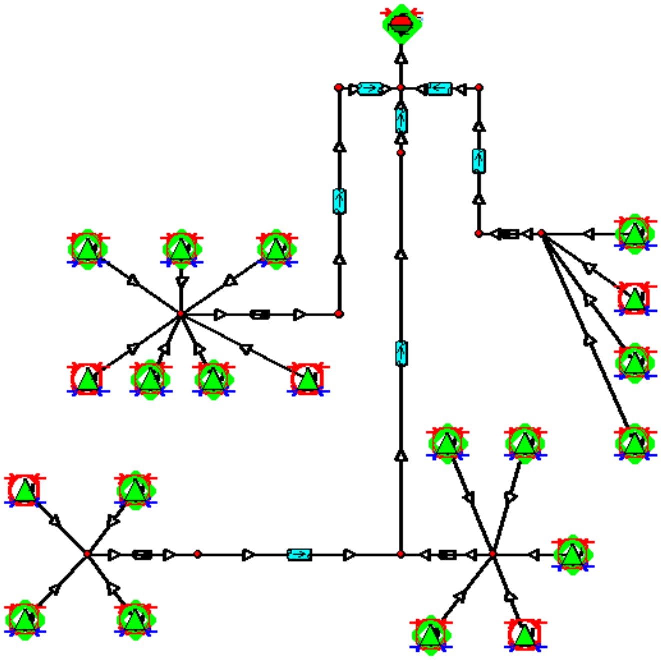
RBNS

GAP Rule Based Network Solver

Introduction

The IPM multiphase surface network optimisation platform, GAP, has been available and used by engineers for almost two decades now. GAP has been instrumental in assisting Engineers to make operational decisions on a daily and long terms forecasting basis. However in the latter context using a ***full rigorous mathematical Non-Linear Optimisation*** for a 40 year forecast may be excessive, and lead to longer run times. The three alternatives (to date) have been:

1. GAP: to perform a prediction using ***no optimisation*** which is faster but the drawback is that no imposed constraints are honoured.
2. OpenServer: to control the wells with some bespoke logic using OpenServer, but the drawback is to create and maintain a bespoke piece of logic
3. RESOLVE: Implement logic in RESOLVE to control the well responses (the drawback of which is to have to create a bespoke pieces of logic).
    - Historically (Using Event driven scheduling)
    - Recently (Using Visual workflows)



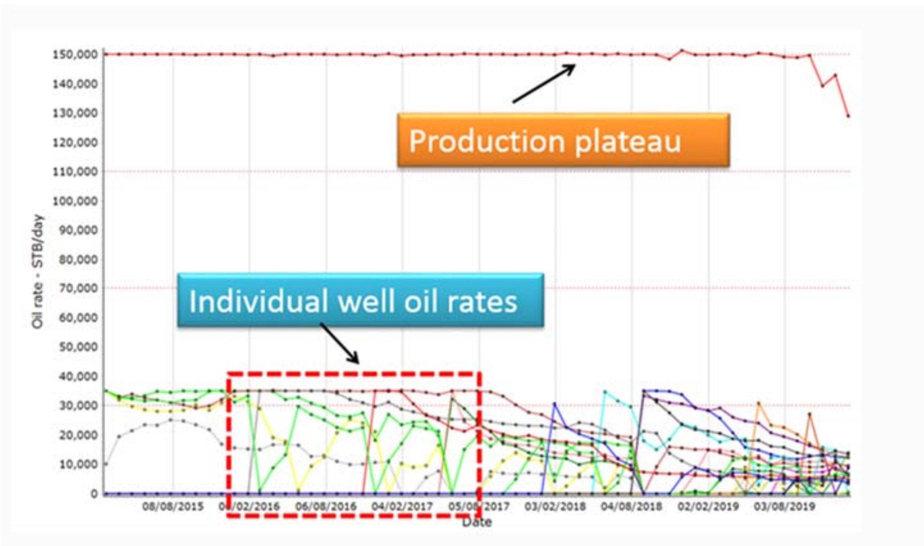
This has left the engineer desiring some kind of halfway house: a simulation that ***does not optimise*** but also ***honours any imposed constraints***. This desire led to the creation of the Rule based Solver (RBS) in IPM9, and is the subject of this article.

Context - Degeneracy

Consider the below offshore system represented in GAP: all the wells are producing at high rates with gas lift gas and wellhead choke control, delivering the commingled fluid to the Floating production Storage and Offloading vessel (FPSO).

As with most FPSO' space is a premium and as such the liquid handling capacity of the separator is limited to 150,000STBD (where each well is limited to 35,000STBD). Each well also have drawdown and gas lift gas constraints.

In this particular context all the wells have a similar watercuts and as such the Optimiser will find multiple control combinations (wellhead chokes, gas lift gas allocation) that satisfy the separator constraint imposed.



This is called degeneracy and at this point the engineer has to assist the optimiser in guiding the algorithm to find a field practical solution. When guidance is not given (in the form of logic) then the optimiser may flip wells on and off from one timestep to the next based upon fractional differences in watercut (see below production rates from an optimised run) the results may be impractical to implement in the field.

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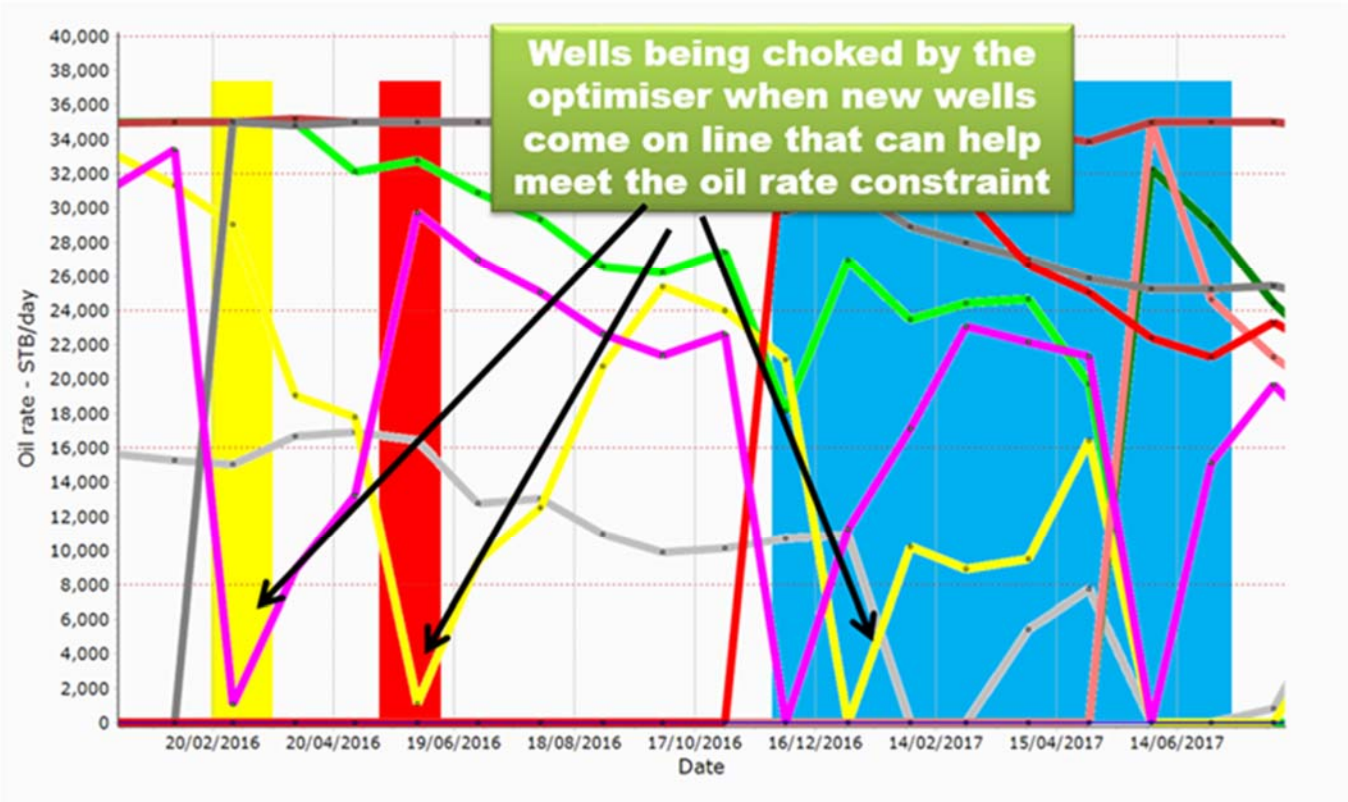
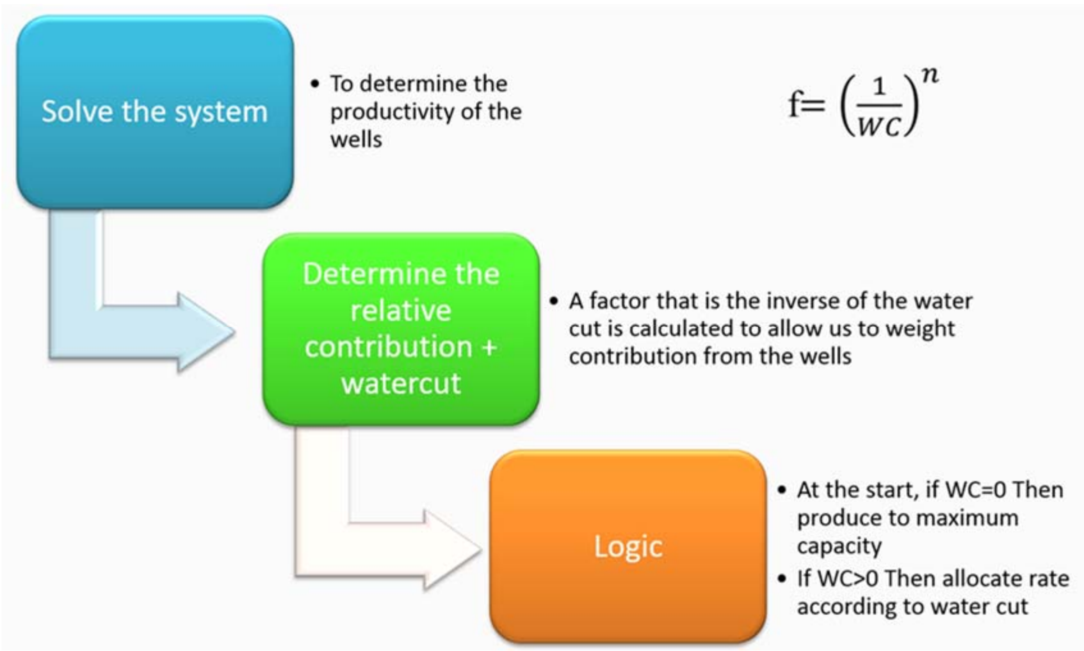


The RESOLVE approach

The logic has been historically defined in RESOLVE (where a controlling logic is defined in Workflows, and within this logic the non-linear optimiser finds the best solution). A watercut based logic is shown below as an example:



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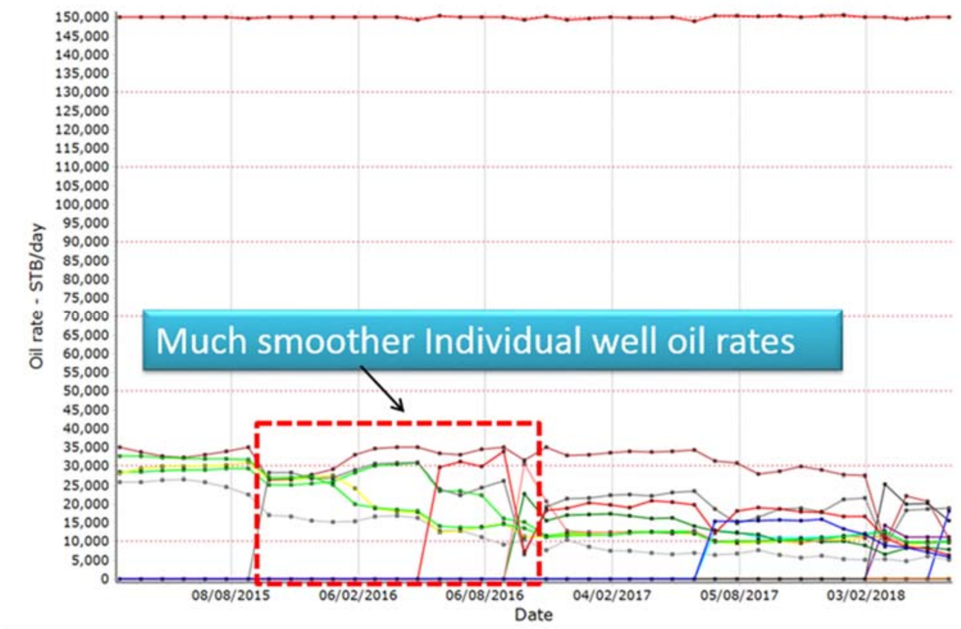
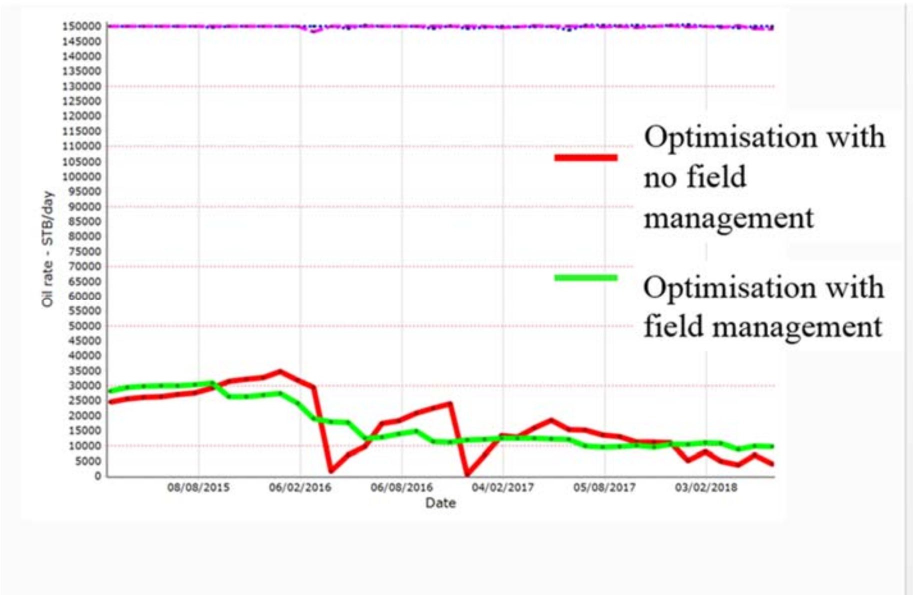
Implementing the above logic shows much smoother profiles, as can be seen below however it must be noted that this logic is achieved by switching off the optimiser, and the cost of doing this can be seen below:



The below screen shot shows the production profile of a single well using the two approaches (optimisation and logic): it can be seen that the logic approach is a much smoother profile, but the cost of this is less production.



The Rule Based Solver Methodology

The above sections justify the development/application of a rules based approach. The Rules based solver approach implemented in IPM9.0 does the following:

- Constrain production from wells until the imposed constraints are honoured
- Allow users to set weightings so that specific wells can be preferentially produced (as would be done in the field)
- Recognise the constraints in a hierarchical way (i.e. the constraints are recognised with respect to position in the surface network, and on which equipment they are applied)
- For powered systems, minimise power consumption before choking wells
- For artificially lifted systems, artificially lift rates (ALQs) are first minimised before choking wells
- For Gas lifted systems (where the response is non-linear and best suited to an optimisation algorithm) uses an "equal returns" approach (i.e. this is better than nothing, and faster than full optimisation)

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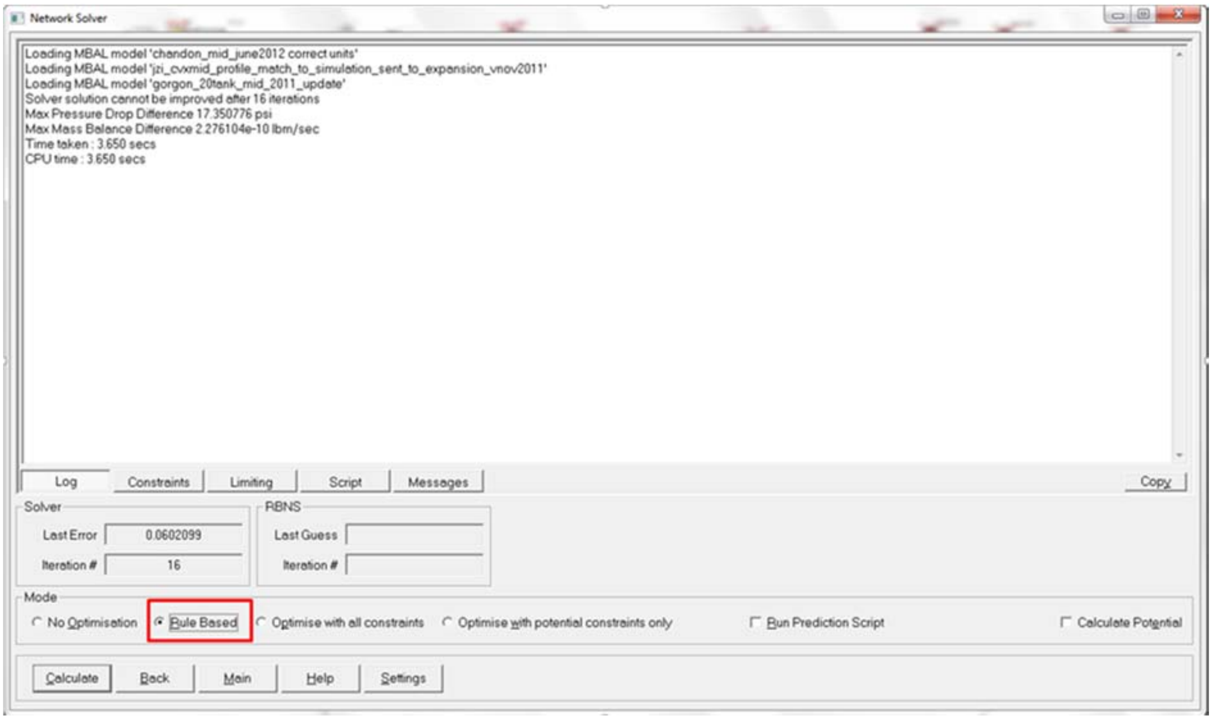
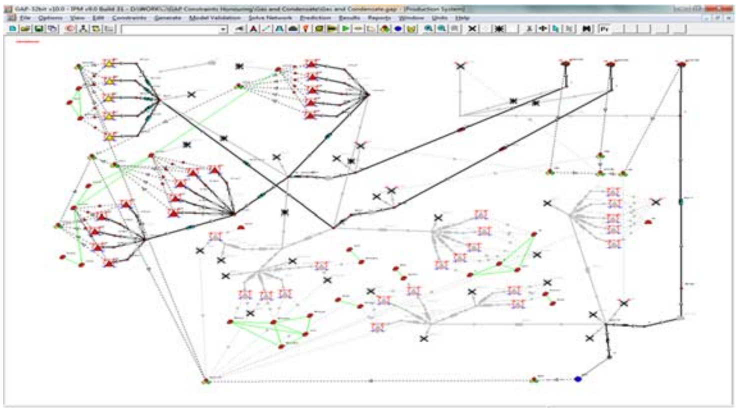
The RBS can be activated from the Solver window in GAP:





Examples

The following section shows two examples of where the RBS has been applied:

1. Gas Condensate System with constraints on the well
2. Large Gas/Oil field with multiple contracts

Example 1

The below GAP model containing gas and condensate producers producing from multiple layers was solved

with (i) Optimisation and (ii) the RBS for a *solve network* and *forecast*. The results are seen below.

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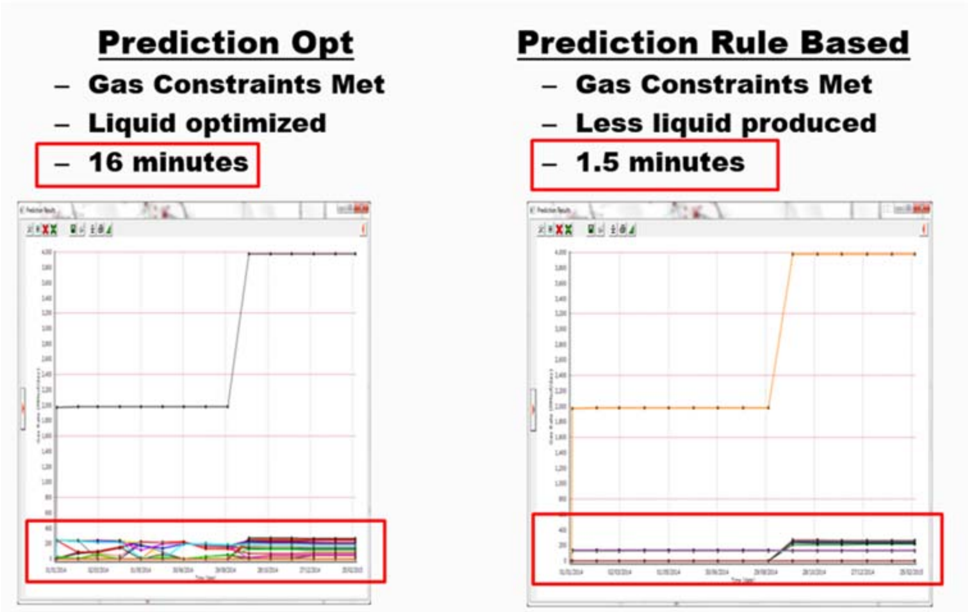


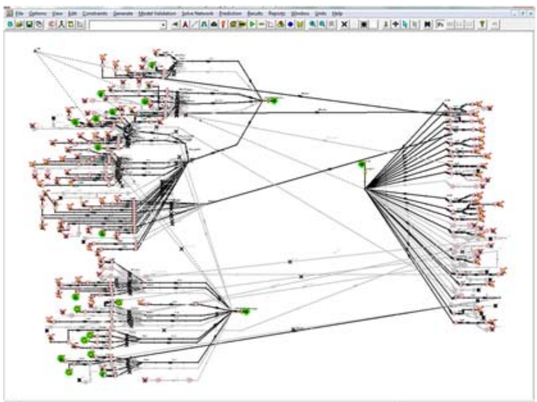
Performing an Optimisation in GAP will give more hydrocarbon than the rule based approach, however in terms of practicality of field operations the RBS is more realistic.

Example 2

The second example is of a large producing field depicted from a Gap screen shot below:

Performing a ***solve network*** shows that the RBS achieve a similar result (approximately 10% less liquid rate) with a significant (97%) reduction in run time.

In this context running a long term forecast quickly is best achieved using the RBS. Of course this magnitude difference is system dependent, and as each system varies so too will the difference.



Discussions

In GAP there are now three modes in which the system can be solved:

- No Optimisation (finds the natural equilibrium of the system as per pressures and mass balances)
- Rule Based (modifies the natural equilibrium to achieve more hydrocarbon by modifying controllable elements using rules – this is not optimisation)
- Optimisation (modifies the natural equilibrium to achieve more hydrocarbon by modifying controllable elements using a rigorous mathematical fully nonlinear optimisation algorithm)

Depending upon the context, the engineer can decide which is most appropriate. If the built in rules are not suitable (despite using well weighting to guide the rules), then the engineer still has the flexibility to build bespoke logic using visual workflows.