Beneficial Role of Humans and AI in a Machine Age of the Telco EcoSystem

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The Case for Artificial Intelligence

Almost out of nowhere AI is dominating the R&D agendas of some of the biggest companies in the world:

"In the long run, I think we will evolve in computing from a mobile-first to an AI-first world, and I do think we [Google] are at the forefront of developments."

- Sundar Pichar, Google

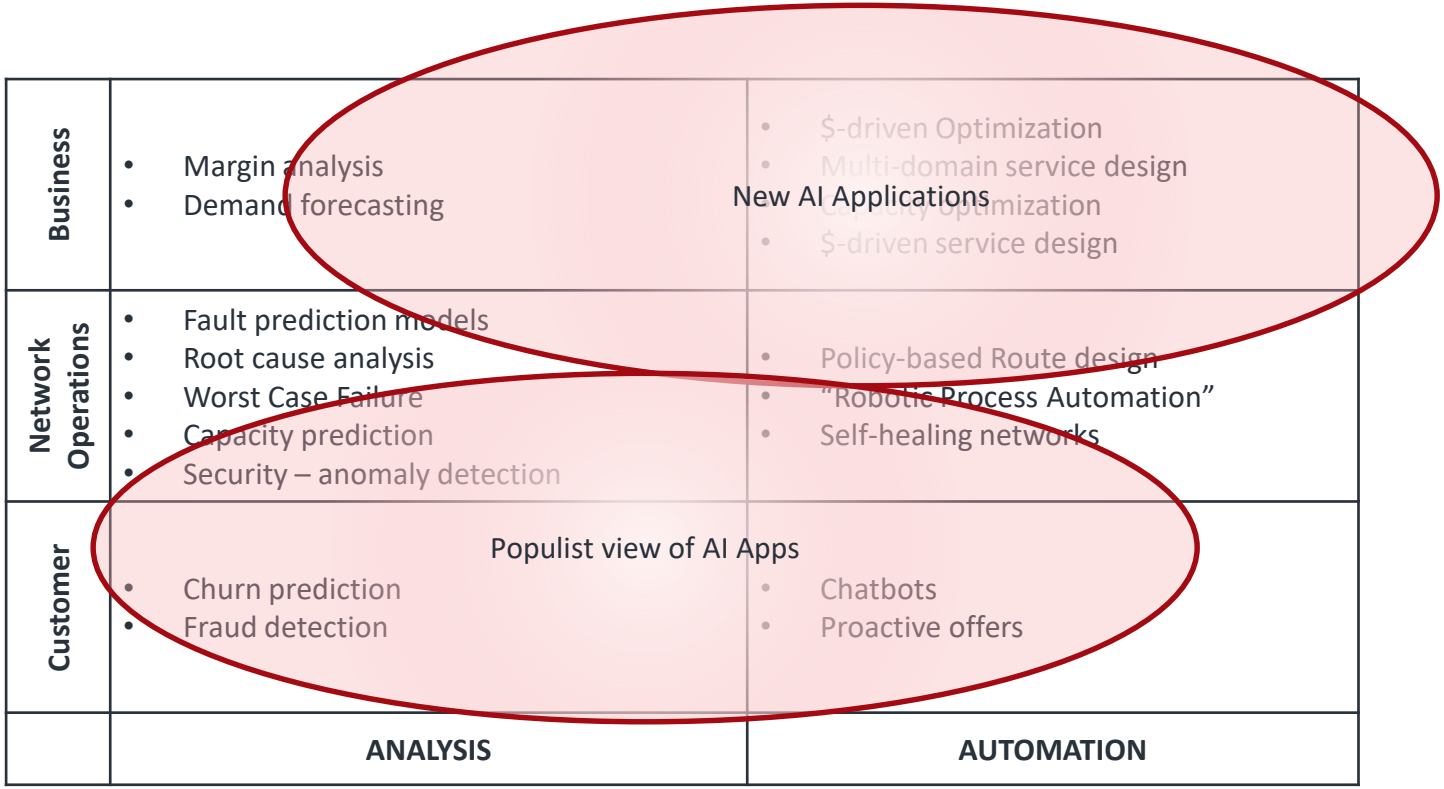
"So the biggest thing that we're focused on with AI is the building of computer services that have better perception that people. I believe that in the next 10 years we will have computer systems that are better at the basic human senses like seeing, hearing, language, i.e. the core things that we do"

- Mark Zuckeberg, Facebook

"Artificial Intelligence will continue to be an unceasing core for Baidu innovations."

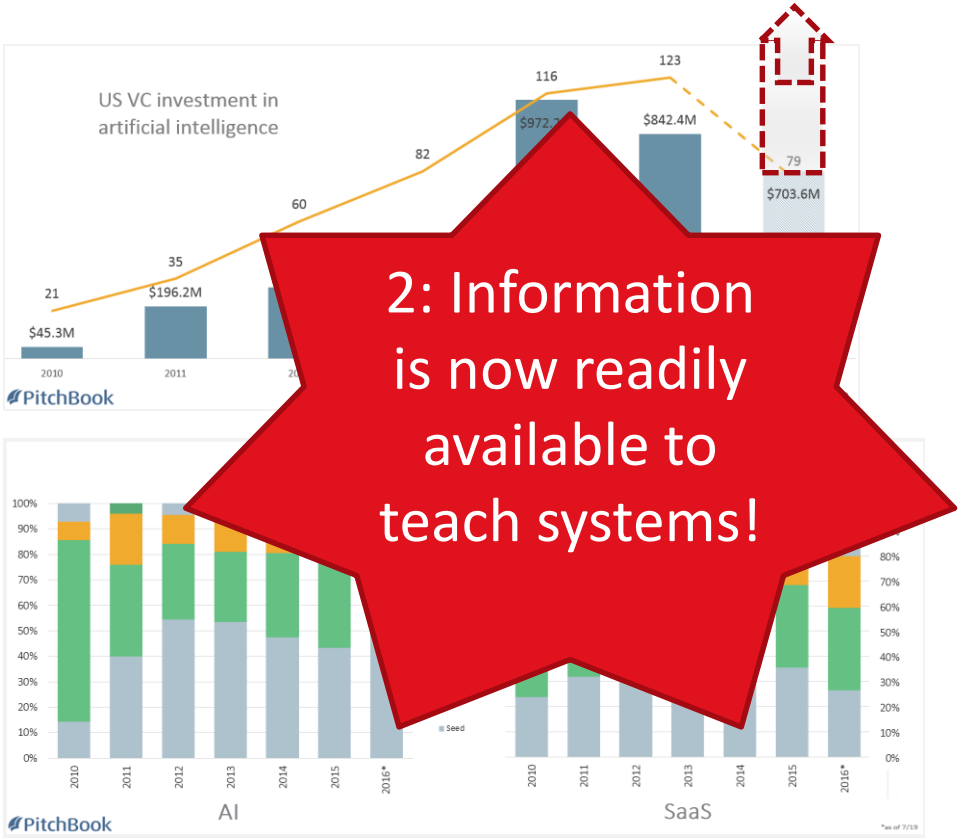
- Robin Li, Baidu

Applications of “AI” in Telecom



Why is the time for AI in Telecoms now?

1 : Its on a strong commercial footing in a number of different industries.



2: Information is now readily available to teach systems!

2016 set to break records for both capital raised and deals completed.

AI as a sector has really started to pick up steam.

However, is there resistance to acceptance of AI?

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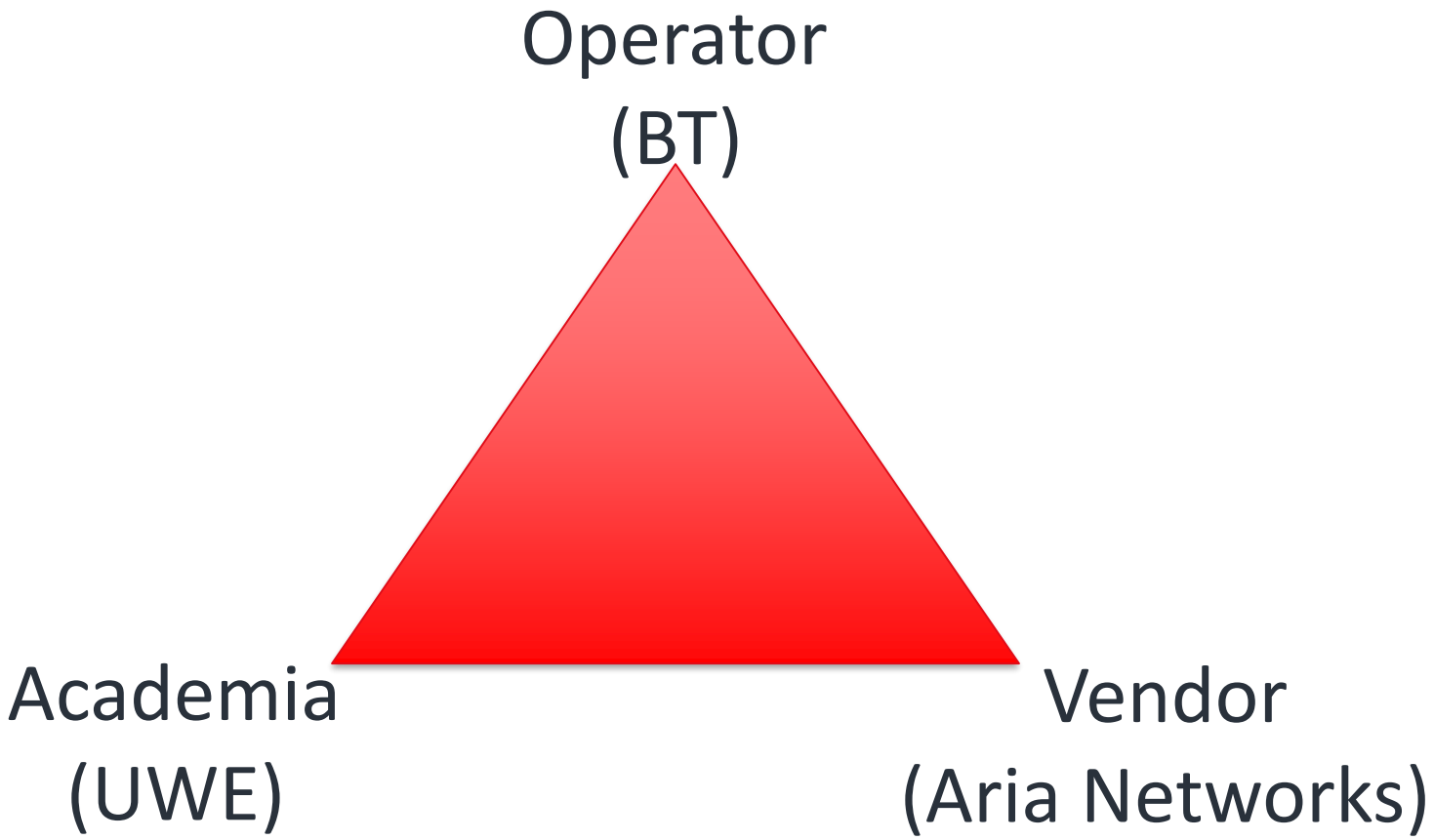
Perceptions, Concerns and Misconceptions

- A perception of AI bringing little or no benefit to network engineering
- A perception that AI is all about Big Data
- A concern that automation will replace the engineer and jobs will be lost
- A concern that control can not be handed over to a machine
- A misconception that it's all about the algorithm and not the person
- A misconception that AI is superior to human intelligence and is to be feared

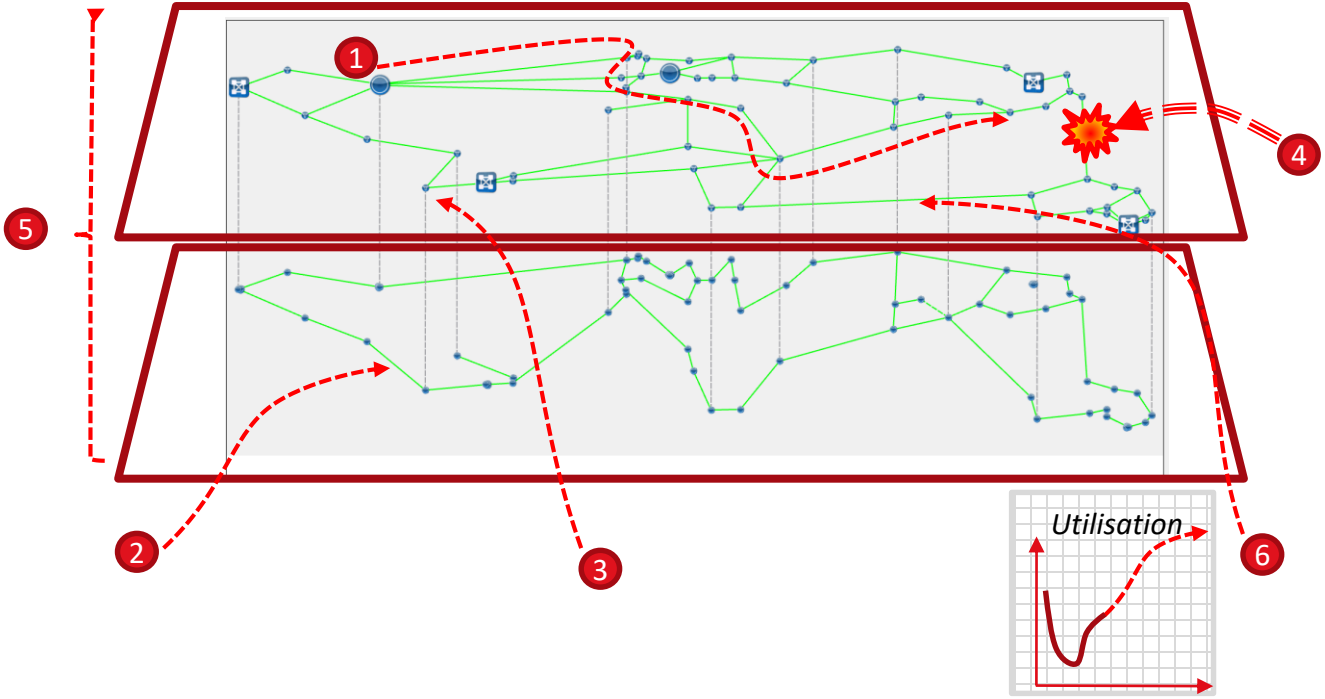
A Balanced Perspective



What areas can AI be applied to ?

1 : Routing (All technologies and Protection)
2 : Dimensioning (How Big Link, Node, Network)
3 : Facility Location (Best place for resources)

4 : Vulnerability Analysis (e.g SRGs, Hot spots)
5 : Multilayer Topology Optimisation (Physical, Virtual, 5G Slices)
6 : Trending and Prediction (Network state at any timescale)



BT activity in network AI

Case study: BT - Supporting national growth through regional R&D partnerships

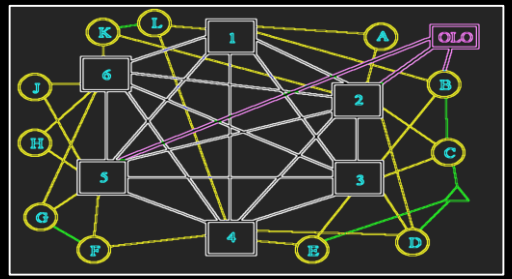
BT is funding AI research at 15 leading universities across the UK, and is the UK's largest telecoms and ICT investor in R&D. In addition, BT is leading a five year, £5m partnership with the Universities of Lancaster, Cambridge, Surrey and Bristol, as part of EPSRC's £78m Prosperity programme, creating an AI powered next generation data infrastructure for the UK. BT is expanding its global R&D centre and startup cluster at Adastral Park in East Anglia. Specifically, BT is committed to creating carrier scale and critical national infrastructure ready AI technology. This is an integral part of the evolving consortium of UK companies and institutions behind a proposed national Future Networks Research Centre with its hub at Adastral Park to drive AI into the global telecoms infrastructure.

Massive technology platform migration
- a complex set of linked impacts and priorities

Service levels

Long and short term costs

Multiple topologies

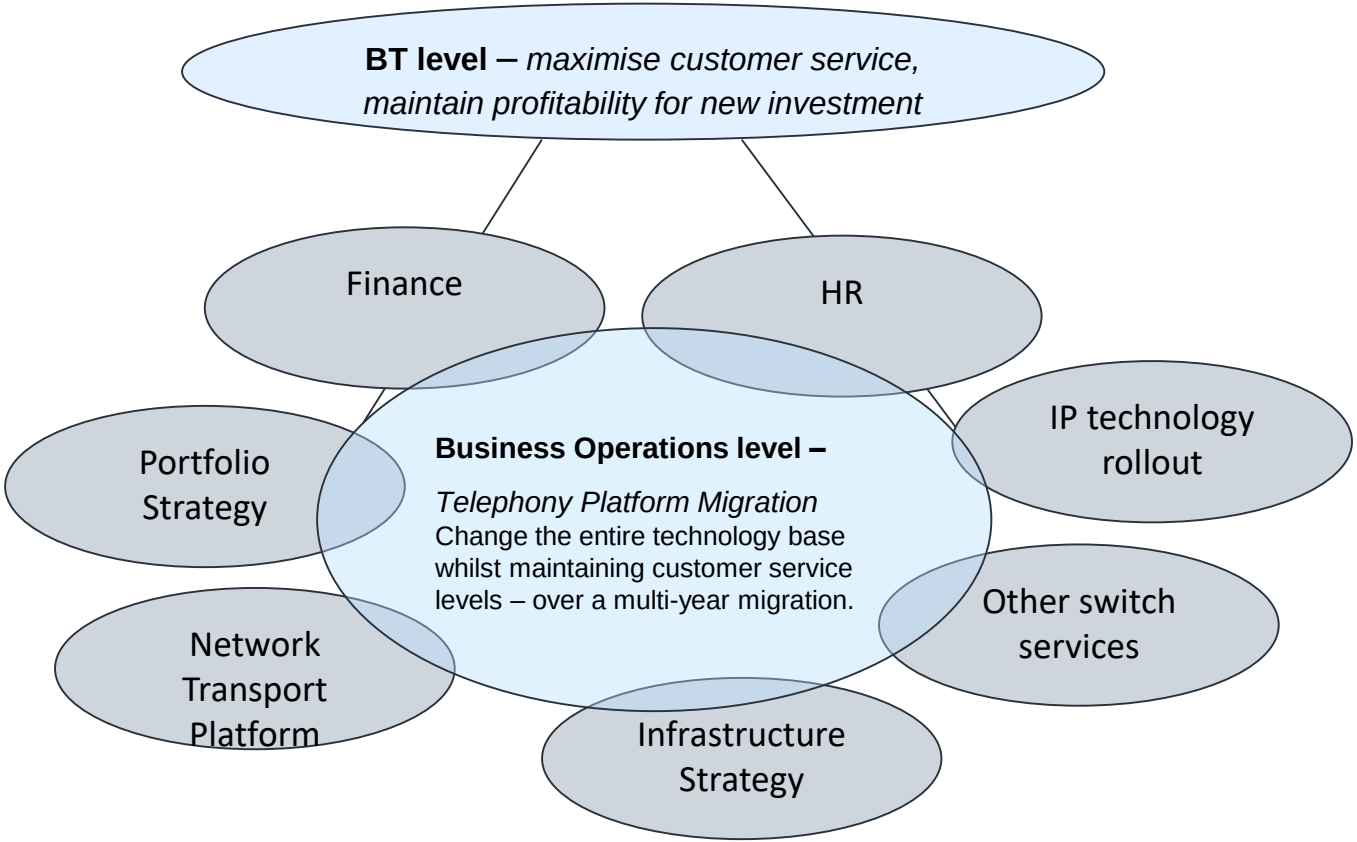


Geography

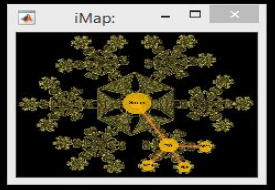
Future skill requirements

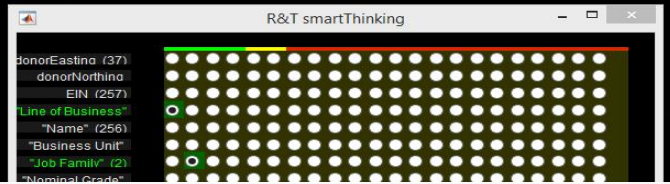
Energy and carbon

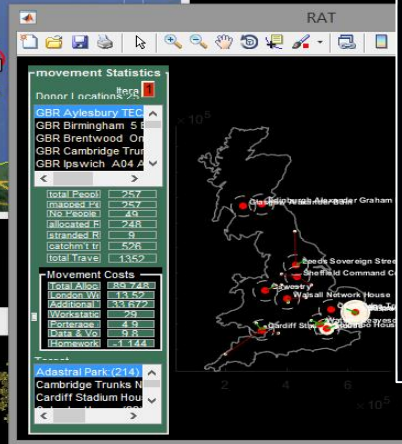
AI model used to generate new ways achieving collaborative solutions across a wide set of stakeholders

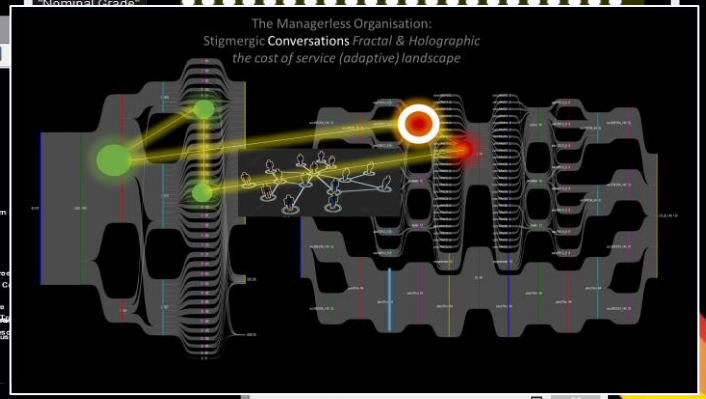


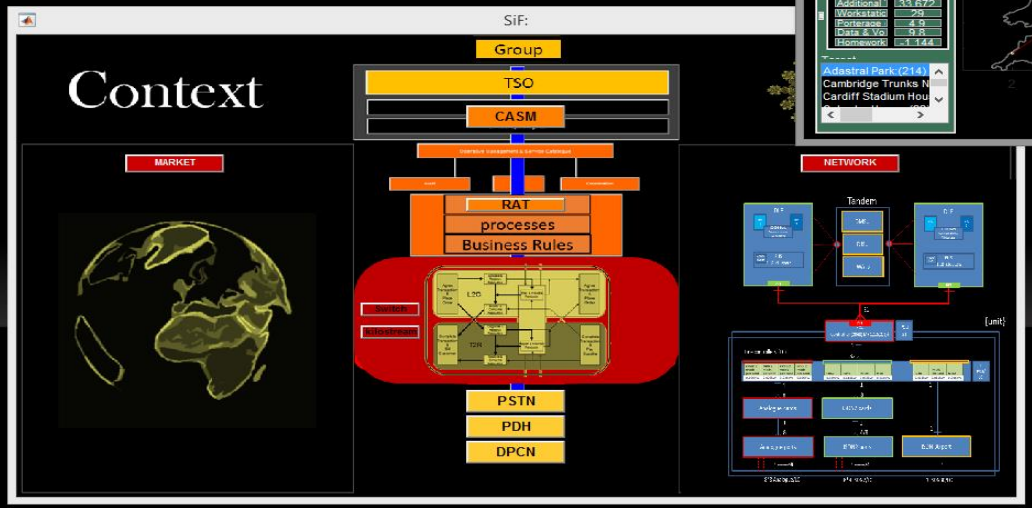
Model interfaces

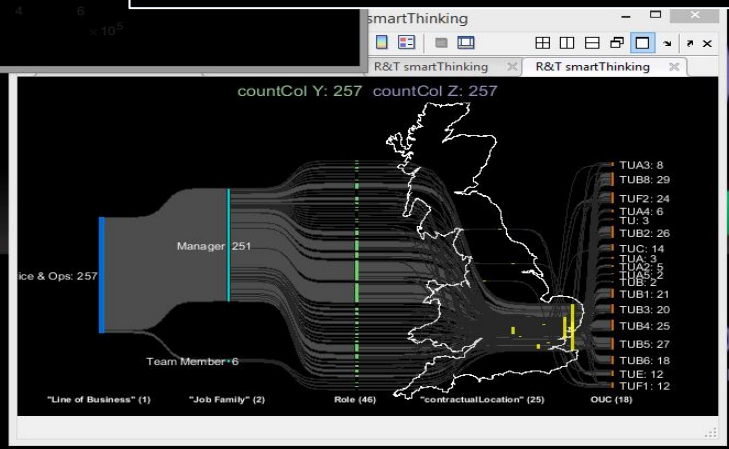








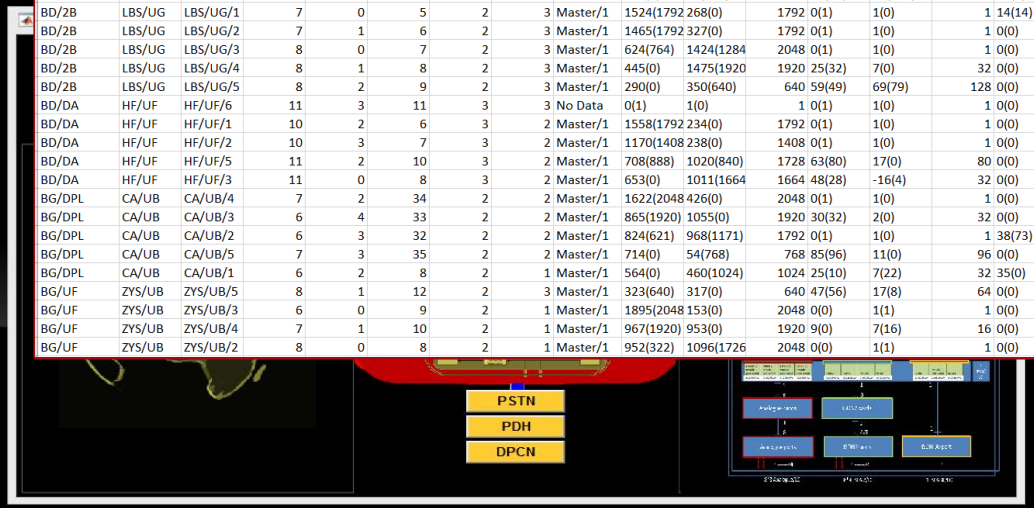




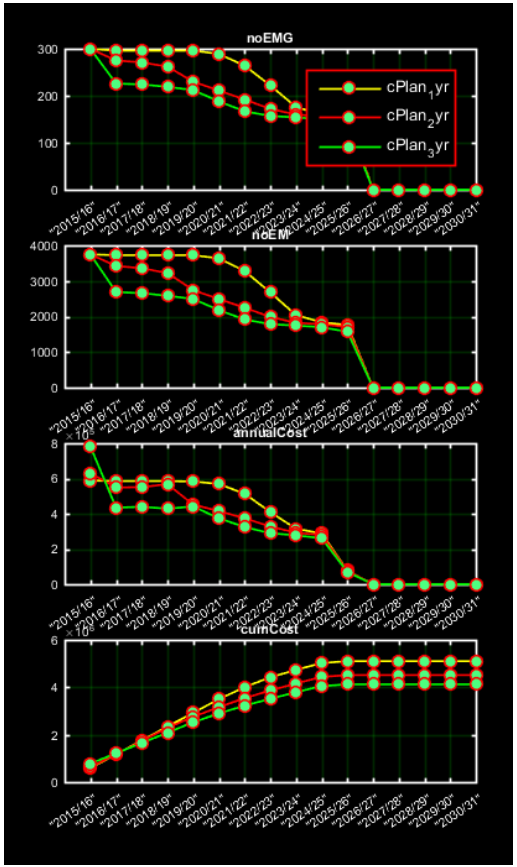
Model outputs

Complete detailed work plan… 17M steps

A1141	unit1141	B1141	TUN	SC	HW	clstr	Mark	lineTest	Aused	Afree	Afitted	I2used	I2free	I2fitted	I30used	I30free	I30fitted
AB/LN/UD	AGV/UB	AGV/UB/5	3	6	48	1	3	No Data	0(1)	1(0)	1	0(1)	1(0)	1	216(268)	52(0)	270
AB/LN/UD	AGV/UB	AGV/UB/3	5	6	38	1	2	Master/1	579(1920)	1341(0)	1920	8(16)	8(0)	16	0(0)	0(0)	0
AB/LN/UD	AGV/UB	AGV/UB/4	5	7	39	1	2	Master/1	272(1024)	752(0)	1024	65(56)	31(40)	96	0(0)	0(0)	0
AB/LN/UD	AGV/UB	AGV/UB/1	3	0	0	1	1	Master/1	1658(77)	198(1779)	1856	0(0)	1(1)	1	75(53)	15(37)	90
AB/LN/UD	AGV/UB	AGV/UB/2	3	1	1	1	1	Master/1	513(0)	1215(1728	1728	0(0)	1(1)	1	30(0)	60(90)	120
ACM/PG	CAM/UE	CAM/UE/1	5	2	35	8	1	Master/1	596(1856)	1260(0)	1856	0(1)	1(0)	1	0(0)	0(0)	0
ACM/PG	CAM/UE	CAM/UE/7	4	1	21	8	1	Master/1	549(451)	795(893)	1344	30(64)	34(0)	64	10(30)	20(0)	30
ACM/PG	CAM/UE	CAM/UE/1	5	0	24	8	1	Master/1	532(0)	748(1280)	1280	0(1)	1(0)	1	0(0)	0(0)	0
ACM/PG	CAM/UE	CAM/UE/6	4	0	20	8	1	Master/1	408(0)	744(1152)	1152	0(1)	1(0)	1	0(0)	30(30)	30
ACM/PG	CAM/UE	CAM/UE/1	3	0	15	8	1	Master/1	222(0)	34(256)	256	96(59)	64(101)	160	20(0)	40(60)	60
BD/2B	LBS/UG	LBS/UG/1	7	0	5	2	3	Master/1	1524(1792	268(0)	1792	0(1)	1(0)	1	14(14)	4(4)	30
BD/2B	LBS/UG	LBS/UG/2	7	1	6	2	3	Master/1	1465(1792	327(0)	1792	0(1)	1(0)	1	0(0)	0(0)	0
BD/2B	LBS/UG	LBS/UG/3	8	0	7	2	3	Master/1	624(764)	1424(1284	2048	0(1)	1(0)	1	0(0)	0(0)	0
BD/2B	LBS/UG	LBS/UG/4	8	1	8	2	3	Master/1	445(0)	1475(1920	1920	25(32)	7(0)	32	0(0)	0(0)	0
BD/2B	LBS/UG	LBS/UG/5	8	2	9	2	3	Master/1	290(0)	350(640)	640	59(49)	69(79)	128	0(0)	0(0)	0
BD/DA	HF/UF	HF/UF/6	11	3	11	3	3	No Data	0(1)	1(0)	1	0(1)	1(0)	1	0(0)	0(0)	0
BD/DA	HF/UF	HF/UF/1	10	2	6	3	2	Master/1	1558(1792	234(0)	1792	0(1)	1(0)	1	0(0)	0(0)	0
BD/DA	HF/UF	HF/UF/2	10	3	7	3	2	Master/1	1170(1408	238(0)	1408	0(1)	1(0)	1	0(0)	0(0)	0
BD/DA	HF/UF	HF/UF/5	11	2	10	3	2	Master/1	708(888)	1020(840)	1728	63(80)	17(0)	80	0(0)	0(0)	0
BD/DA	HF/UF	HF/UF/3	11	0	8	3	2	Master/1	653(0)	1011(1664	1664	48(28)	-16(4)	32	0(0)	0(0)	0
BG/DPL	CA/UB	CA/UB/4	7	2	34	2	2	Master/1	1622(2048	426(0)	2048	0(1)	1(0)	1	0(0)	0(0)	0
BG/DPL	CA/UB	CA/UB/3	6	4	33	2	2	Master/1	865(1920)	1055(0)	1920	30(32)	2(0)	32	0(0)	0(0)	0
BG/DPL	CA/UB	CA/UB/2	6	3	32	2	2	Master/1	824(621)	968(1171)	1792	0(1)	1(0)	1	38(73)	102(67)	150
BG/DPL	CA/UB	CA/UB/5	7	3	35	2	2	Master/1	714(0)	54(768)	768	85(96)	11(0)	96	0(0)	0(0)	0
BG/DPL	CA/UB	CA/UB/1	6	2	8	2	1	Master/1	564(0)	460(1024)	1024	25(10)	7(22)	32	35(0)	200(235)	240
BG/UF	ZYS/UB	ZYS/UB/5	8	1	12	2	3	Master/1	323(640)	317(0)	640	47(56)	17(8)	64	0(0)	0(0)	0
BG/UF	ZYS/UB	ZYS/UB/3	6	0	9	2	1	Master/1	1895(2048	153(0)	2048	0(0)	1(1)	1	0(0)	0(0)	0
BG/UF	ZYS/UB	ZYS/UB/4	7	1	10	2	1	Master/1	967(1920)	953(0)	1920	9(0)	7(16)	16	0(0)	0(0)	0
BG/UF	ZYS/UB	ZYS/UB/2	8	0	8	2	1	Master/1	952(322)	1096(1726	2048	0(0)	1(1)	1	0(0)	0(0)	0



Multi-year costs, system size, etc…



Theoretical study bears out a non-intuitive conclusion

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Humans and AI can work together for all manner of problems

- **Single Objective** (e.g. either link metric, hops, delay)
  - Once a human helps train/code an AI or machine then this the computer can react in “reflex time”.

- **Multi-Objective** (i.e. 2-4 objectives, e.g. maximise margin and equipment reuse but minimise delay)
  - Objectives needs to be balanced and human expertise and intuition can help develop a compromise between, what could be, conflicting requirements.
  - In this case the assessment of each event can happen in process time but changing business/technical needs requires a long human interaction and analysis

- **Many Objective** (Combinatorically very large, e.g. platform migration – routinely $>10^{50}$-10^{80})
  - This is beyond any computation system to store, let alone compute optimal trajectories in sensible time scales
  - AI can be used to steer human intuition and creation to get better results, previously undiscoverable

Trust and Acceptance in AI

AI results can sometimes be 'black box' and opaque, so…

"to be a team player, an intelligent agent, like a human, must be reasonably predictable and reasonably able to predict others actions"

G. Klien, Woods, et al. (2004) "Ten challenges for making automation a "team player" in joint human-agent activity," *IEEE Intelligent Systems*, vol. 19, no. 6, pp. 91–95.

Research at UWE, Bristol, UK has incorporated engineer interaction in software development:

"Results show that [interactive optimization] is speedy, responsive and effective in enabling dynamic multi-objective [AI]. Indeed, study participants rate the experience as compelling"

Simons, Smith (2012) "Elegant Object-oriented Software Design via Interactive Evolutionary Computation", *IEEE Transactions on Systems*, *Man and Cybernetics – Part C*, vol 42, no. 6, pp. 1797-1805.

Simons, Smith, White (2014) Interactive Ant Colony Optimisation (iACO) for Early Lifecycle Software Design, *Swarm Intelligence*, vol. 8, no. 2, pp. 139-157.

AI and Humans in Partnership

We conclude that AI and Humans can and should operate *together*:

- From the point of view of the ***Operator***
  - To embrace an interactive, human “in-the-loop” AI optimization approach
- From the perspective of the network planning/optimisation solution ***Vendor***
  - To augment AI/human interaction into the design and operation of solutions
- From the point of view of the Academic ***Researcher***
  - To validate novel and innovative algorithms against case studies of realistic scale and complexity

Download a copy of a discussion document on which these slides are based at

https://github.com/christopher-simons/BeneficialRole