



orbit # 37

ORbit

medlemsblad for Dansk Selskab
for Operationsanalyse og Svenska
Operationsanalys- föreningen

Redaktion:

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Næste deadline:

10. Marts 2022

Tryk:

Ecograf Gruppen

Oplag: 390

ISSN: 1601-8893

Forside:

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Editor

Being a member of DORS for close to 8 years and a reader of ORbit since then, it was hard for me to find words for my first ever editor note, knowing that I have big shoes to fill. We say goodbye to Julia as Editor and thank her for the commitment towards making ORbit an enjoyable read over the past years! Personally, I would also like to thank her for the immense help in this transition period and getting started with my first issue - for which I take full responsibility about the delay in getting out.

We are slightly on the low end in number of articles for this issue, but we are definitely on the high end in quality of these. I hope you enjoy sitting back with a cup of your favourite beverage while Jakob Krarup takes you on a journey through the history of DASK. Don't forget to check out how Tobias Karlsson solved cable harness routing and took home the prize for the best Swedish Master thesis in 2020. While you are at it, let's stay in Sweden and read about how metaheuristics in research changed the perspective of Michael Patriksson. Last but not least, Baptiste Coutton tells us about the Multi-class Constrained Bin Packing Problem that he is working on in his PhD.

Enjoy your reading and see you in 2022!

Best, João Fonseca (Editor)

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Nu är hösten här igen, och för första gången sedan jag valdes till ordförande för SOAF våren 2020 börjar livet så sakteliga återgå till ett något mera normalt tillstånd efter COVID-pandemin. Personligen jobbar jag fortfarande hemifrån de flesta dagarna i veckan, men vi börjar ändå kunna återgå till att ha en del normala möten och även diskussioner om hur arbetet efter COVID ska arrangeras på bästa sätt.

Sedan i våras har ett par olika saker hänt inom arbetet i SOAFs styrelse. Vi har dragit igång en virtuell seminarieserie där vi hittills har fått höra Patrik Alfredsson prata om 'Life Cycle Management' och Björn Morén berätta om 'What can optimization contribute to in high dose-rate brachytherapy?'. Vår ambition är att hålla ett seminarium per kvartal, och vi hoppas kunna skicka ut detaljer om nästa seminarium inom ett par veckor.

SOAFs styrelse har också börjat arbetet med nästa Svenska Operationsanalyskonferens, SOAK. Normalt anordnas SOAK under hösten på udda år, men för att kunna anordna en fysisk konferens beslutade vi under året att skjuta upp årets version till vecka 11 under våren 2022. Styrelsen har nyligen beslutat var SOAK kommer att hållas, och vi hoppas att snart kunna skicka ut de första detaljerna. Vi ser verkligen fram mot att träffa hela det svenska operationsanalys-nätverket igen!

Vi har även öppnat SOAFs exjobbspris 2021 för nomineringar. Om du har utfört, handlett eller känner till ett exjobb som använder operationsanalysmetoder för att förbättra beslutsunderlag, besök soaf.se för mer detaljer om hur nomineringen går till.

Till sist vill vi skicka en stor gratulation till våra danska kollegor i DORS efter att Köpenhamn under sommaren blev utvalt att anordna EURO-konferensen 2024. Nästa års konferens kommer som bekant att anordnas i Espoo, och redan 2024 kommer alltså konferensen tillbaka till ett av våra grannländer, vilket verkligen är jätteroligt!

Mattias Grönkvist, Ordförande, SOAF

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Optimization of cable harness routing

by Tobias Karlsson (2020 best Master thesis within OR in Sweden)

Fraunhofer-Chalmers Centre (FCC) is a research centre in industrial mathematics that offers research, software, and services for a broad range of industrial applications. In the software Industrial Path Solution (IPS), developed by FCC, there exist solutions to automatically route cables with respect to design constraints such as minimum bending radius and minimum clearance. However, no solution for routing several cables to automatically create harness designs exists; the SOAF-award 2020 winning master thesis [1] was initiated with the aim to develop such a solution.



A cable harness is an assembly of cables or wires, see Figure 1. There are several advantages of having cable harnesses, such as the amount of space needed for the cables can be reduced, the increased security, and the time of installation can be reduced. It is common that routing designs are done manually in a CAD environment and when many requirements of the routing design must be considered, this task can become complicated and very time consuming. By automating the cable harness routing process several benefits can be achieved, e.g., the process can become less time consuming, and costs can be reduced by optimizing the routing layout.

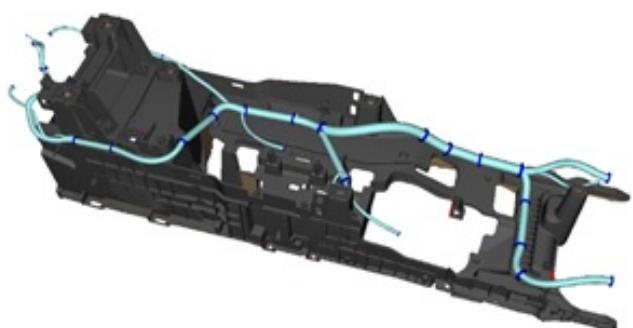


Figure 1: A cable harness routing.

There are many aspects and requirements that can

be considered when designing harnesses; the ones considered in the developed model in [1] are the following:

- The length of the cables
- The amount of space used by the cables
- Collision free routes
- Minimum clearances
- (Non-)preferable zones to route in

What a good harness design is can be subjective and it can be difficult to create a generic model that captures all aspects of a desired design for every specific case. This was a motivation to develop a model that gives the harness designer user-friendly flexibility to set up problem instances in a way that results in desired harnesses. A strength with the developed model is that we get a variety of different topological routings when solving the corresponding optimization problem.

The problem to automatically create harness designs has been investigated before using artificial intelligence, for example by using genetic algorithms [2]; this made it even more interesting to investigate the possibilities to solve the problem using classical optimization, as in [1], and the results are very promising.

Modelling the cable harness routing problem

We formulate the Cable Harness Routing Problem (CHRP) as a multi-objective Mixed Integer Linear Programming (MILP) model on a directed graph. The approach is to discretize a 3D space with grid points as illustrated in Figure 2. The discretized space encloses some given start and end nodes locations to route between. The nodes in the graph represent the grid points, and the arcs represent the physical paths a cable can take. For an arbitrary node, the arcs connect it to a neighbourhood of nodes; the neighbourhood is defined as taking a discrete step in at least one of the x, y and z dimensions, as illustrated in Figure 3.

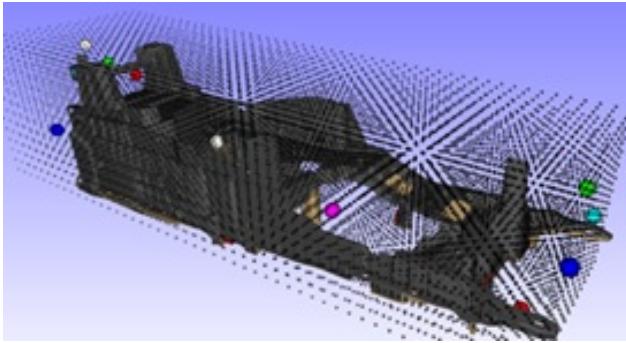


Figure 2: A discretized 3D space around some collision geometry and colored start/end node pairs.

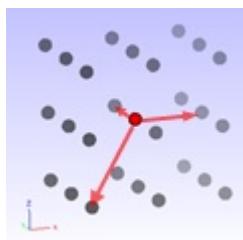


Figure 3: Arcs can be traversed from the red node to the dark nodes.

The model consists of two conflicting objective functions, f_{SP} and f_h , and we create one compound objective function by a weighted sum formulated as

$$w_{SP}f_{SP}(\mathbf{y}) + w_h f_h(\mathbf{x}) \quad (1)$$

with non-negative weights w_{SP} and w_h . The vector \mathbf{y} represent which arcs that are used in the graph and $f_{SP}(\mathbf{y})$ is the sum of the lengths of the cable paths; by minimizing f_{SP} we get shorter paths. For $w_h = 0$, the CHRP reduces to a shortest path problem for each cable. For $w_h \neq 0$, the harnessing, or bundling, aspect comes in. The vector \mathbf{x} represent which nodes that are used in the graph; usage of a node means that it is included in a route for at least one cable, which contributes to a penalty with an associated node cost. By minimizing f_h the cables use as few and cheap nodes as possible.

Connection between the CHRP model and the harness design requirements

With the two objective functions, we consider the first two mentioned harness requirements above: having short cables and to reduce the usage of space, or in other words, to bundle the cables together. The requirements of having collision free paths and minimum

clearances are simply satisfied by removing appropriate nodes from the graph.

The last requirement mentioned above, i.e., routing with respect to preferable or non-preferable zones, is considered by adjusting the node costs. In a harness design, it is common to route close to geometries where the bundles of cables should be fastened and to avoid hazardous zones. Figure 4 shows the result of a user-friendly implementation of automatically setting the node costs as a function of the distance to the collision geometry; the costs depend on whether it is desirable to avoid or to route close to the geometry.

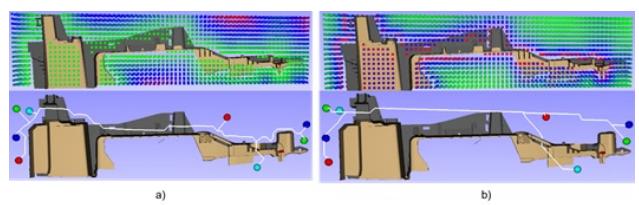


Figure 4: Cross section of some collision geometry and a discretized grid. The node costs are visualized as a heat map varying between green (cheap), blue (intermediate) and red (expensive). a) preferable to route close to the geometry. b) routes should avoid the geometry. The white lines represent an optimized harness routing for the corresponding node costs in a) and b).

The objective function weights w_{SP} and w_h represent how much we prefer to minimize the objective functions relative to each other; the weights can be modified to obtain a subjectively preferred solution. In practice, we solve the problem for a set of weights from which topologically different routing solutions are obtained. A routing solution corresponds to a point in the objective functions space for some specific objective weights. In Figure 5, the CHRP has been optimized for a range of objective weights where two routing solutions are depicted with their corresponding points in the objective functions space. We can see in Figure 5 that when f_{SP} is decreased and f_h is increased, it results in a solution with less bundling, but more individual shorter paths for the cables.

Lagrangian relaxation of the CHRP

For industrial-sized cases, the CHRP results in a large-scale optimization problem, and the problem becomes too time consuming to solve using a MILP solver. For this reason, we apply Lagrangian relaxation and uses a deflected subgradient algorithm, presented in [3], to solve the Lagrangian dual problem. To find good primal solutions, several specially adapted heuristics have

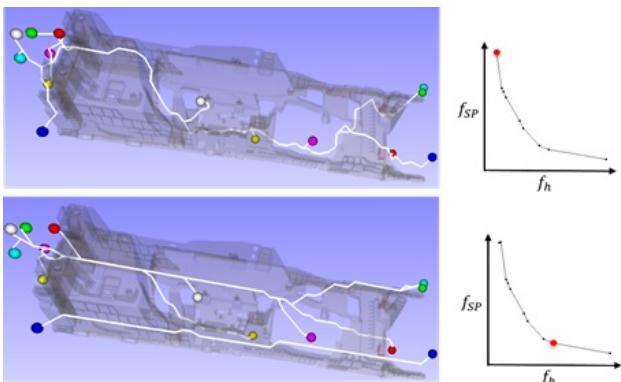


Figure 5: Two optimized harness routings corresponding to the red points in the objective functions space. The white lines represent the optimized cable routes between the colored start/end node pairs. The collision geometry is visualized as transparent.

been developed.

A comparison in computation times between solving the CHRP with a MILP solver and using the subgradient algorithm is presented in Figure 6. The subgradient algorithm was set to terminate when reaching a small relative duality gap equal to 0.01% or when it converged, and it resulted in gaps in the range 0.01%-0.17%; this means near-optimal solutions were found. The relative duality gap is calculated from the bounds on the optimal objective value as $(UB - LB)/LB$, with UB being the upper bound and LB being the lower bound.

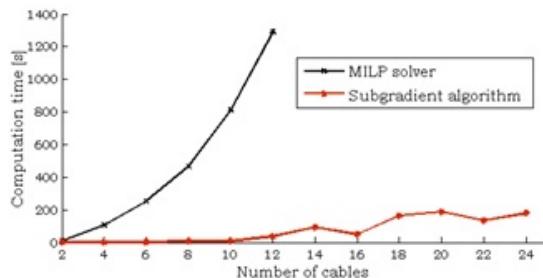


Figure 6: Computation time (in seconds) for solving the CHRP using a commercial MILP solver vs using the subgradient algorithm. The time was measured for problem instances with the same collision geometry, a grid size equal to (40, 13, 11) in dimensions (x, y, z), and increasing number of cables.

Conclusions

There are promising possibilities to use the developed model as a tool for creating harness routings since the model captures several important harness design aspects and requirements. There is interest to keep developing user-friendly solutions to set up and solve

problem instances, and to use the routing solutions for further processing, such as designing of fasteners, creating cable geometry, and satisfying bend radii constraints.

The developed solution and algorithm have shown to be efficient for several test cases. The results have generated interest for further development of our algorithm, such as fine-tuning the algorithm, and creating efficient heuristics.

References

- [1] T. Karlsson (2020) *Optimization of Cable Harness Routing*, Chalmers University of Technology, Gothenburg.
- [2] W. Pemarathne and T. Fernando (2016) *Wire and cable routings and harness designing systems with AI, a review*, 2016 IEEE International Conference on Information and Automation for Sustainability (ICIAfS), pp. 1-6. IEEE.
- [3] R. Belgacem and A. Amir (2018) *A new modified deflected subgradient method*, Journal of King Saud University-Science, vol. 30, no. 4, pp. 561–567.



Tobias Karlsson graduated from Chalmers University of Technology in 2020 and is currently working at the Fraunhofer-Chalmers Research Centre for Industrial Mathematics.

DORS prize 2021

by Beizhen Jia

Call for candidates

DORS hereby asks for candidates for Denmark's best master thesis project in Operations Research. The invitation is open for all and not just members of DORS - so please share.

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- The thesis is written in Danish or English
- The thesis has been defended in 2021

The committee will put emphasis on analyzing and solving practical problems when selecting the best thesis.

How to apply

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- The grade obtained at the public defense of the thesis
- Email addresses and phone numbers on the authors of the thesis and the supervisor

The process and rules

After the thesis is handed in the following occurs:

- DORS sets up a committee of three people to asses the candidates
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- In the end of March 2022, the committee appoints a winner and informs all the participants

- The prize is awarded at the General Assembly of DORS in April 2022. The prize is of 5000 DKK to share between the authors of the thesis.
- To receive the prize and the money, the authors are required to present the thesis at the General Assembly of DORS and to write a short article to ORbit regarding the thesis.

Please feel free to write to dors@dorsnet.dk if you have any questions.

I begyndelsen var BESK og DASK...

by Jakob Krarup

Per Gjerlov, civilingeniør, IT-pioner og i vide kredse anerkendt for et omfattende forfatterskab af fagbøger, fyldte 90 den 23. juli 2020. Som bosat i Allerød nord for København blev han dagen før hædret med en fødselsdagsomtale i "Allerød Nyt". Bladets daværende medarbejder Kristina Pihl skrev smukt om fødselarens omfattende karriere i ind- og udland; herunder at han "... gennem sin ansættelse ved IBM var med til at udvikle Danmarks første computer – en maskine der fyldte 200 kvm og kostede 200 millioner kroner".

Computer-pioner fylder 90 år

Per Gjerlov fra Lillerød fylder rundt den 23. juli
Af Kristina Pihl

FØDSELSDAG Fra sin lejlighed i Lillerød kom Per Gjerlov tilbage på et langt og spændende liv, der har brudt på alt fra længere arbejdsopphold i Sverige og Saudi-Arabien til delfinlyk på Bahamas.

Torsdag den 23. juli fylder han 90 år, og familie og venner er inviteret til at fejre den runde fødselsdag.

Danmarks første computer

Det er altid godt at vide, hvordan andre mennesker har det, hvordan de tænker og opfører sig

Per Gjerlov

Hjemme hos Per Gjerlov er computeren stort set erstattet af en iPad.
Foto: Kristina Pihl

Figure 1: Fødselsdagsomtale i Allerød Nyt den 20. juli 2020.



Figure 2: DOS håndbogen – udkommet i 7 udgaver og nok det mest kendte værk af Per Gjerlov.

IBM-maskinen installeret i 1965: Er det Danmarks første computer eller historieforfalskning? Ved et tilfælde faldt jeg over fødselsdagsomtalen og følte mig provokeret til at bringe læsere af "Allerød Nyt" ud af

vildfarelsen. Efter en indledende korrespondance med chefredaktør Jens Berg Thomsen blev jeg opfordret til at skrive et korrektiv, der med titlen "DASK, Danmarks første computer" blev bragt i "Allerød Nyt" den 14. april 2021.

En venlig læser af artiklen gjorde mig opmærksom på at Sverige kom først og at DASK retfærdigvis måtte anses som en videreudvikling af den svenskbyggede BESK. Dette er aldeles ubestrideligt; meget om dette er allerede fortalt andetsteds, men historien tåler nok at blive genfortalt, thi hvem kan huske, eller aldrig at have hørt om hvad der skete for snart 70 år siden?

BARK og BESK

Enhver beretning om udviklingen i Sverige fra omkring 1950 bør for god ordens skyld indledes med en omtale af BARK, forløberen for BESK. Her følger et par let redigerede uddrag fra "Wikipedia, the free encyclopedia":

- **BARK:** Binär Aritmetisk (Automatisk) Relä-Kalkylator, was an early electromechanical computer. BARK was built using standard telephone relays, implementing a 32-bit binary machine. It could perform addition in 150 ms and multiplication in 250 ms. It had a memory with 50 registers and 100 constants. It was later expanded to double the memory. Howard Aiken, the designer of IBMs Harvard Mark 1 computer, stated with reference to BARK "This is the first computer I have seen outside Harvard that actually works."
- BARK was developed by Matematikmaskinnämnden (Swedish Board for Computing Machinery) a few years before BESK. The machine was built with 8,000 standard telephone relays, 80 km of cable and with 175,000 soldering points. Programming was done by plugboard. It was completed in February 1950 at a cost of 400,000 SEK, became operational on April 28, 1950, and was taken offline on September 22, 1954.
- BESK, Binär Elektronisk SekvensKalkylator, was Sweden's first electronic computer, also developed by Matematikmaskinnämnden but using vacuum tubes instead of relays. It was for a short time the fastest computer in the world. The computer

was completed in 1953 and in use until 1966. The technology behind BESK was later continued with the transistorized FACIT EDB and FACIT EDB-3 machines, both software compatible with BESK. Non-compatible machines highly inspired by BESK were SMIL made for the University of Lund, SAABs rækneautomat SARA and DASK made in Denmark.



Figure 3: *Cand. polit. Aage Melbye (1932-2016) ved DASKs kontrolbord.*

John von Neumann, professor ved Institute for Advanced Study, Princeton University, beskrev i 1945 i samarbejde med to kolleger designet af en computer med styreenhed og regneenhed (CPU), et internt arbejdslager og enheder til ind og udlæsning. En klassisk konstruktion som stadig er gældende for vore dages computere og telefoner. De fastslag desuden, at programmet skulle lagres i selve hukommelsen og ikke bare læses ind undervejs. Både BESK og senere efterfølgere er bygget efter disse principper.

Udviklingen i Danmark

Den centrale figur i udviklingen i Danmark er dr. phil. Richard Petersen (1894-1968), Danmarks første professor i anvendt matematik fra 1954 til pensioneringen i 1964. Hvor nær forskningen end stod hans hjerte, vil mindet om Richard Petersen – omtalt af alle med ærbødighed og ganske uden malice som "Lille p" men aldrig tiltalt således – ikke leve først og fremmest på grund af hans videnskabelige arbejder,

men derimod for et umådeligt livsværk, der kom til at dele sig i to: en lærergerning af enestående omfang og karat, og indsatsen som drivkraft og organisator ved bygningen af DASK, Danmarks første elektroniske cifferregnemaskine.

I 1940 blev "Lille p" medlem af Akademiet for de Tekniske Videnskaber (ATV) og i 1947 formand for et udvalg med den opgave at "følge udviklingen på de moderne regnemaskiners område". I 1955 lykkedes "Lille p" efter langvarige forhandlinger at opnå en bevilling på 900.000 kr. af Marshallhjælpens counter-part-midler til bygning af en elektronisk cifferregnemaskine. Samme år blev Regnecentralen (RC), Dansk Institut for Matematikmaskiner, oprettet til det formål som en selvejende institution under ATV med "Lille p" som bestyrelsesmedlem indtil 1964 og formand 1955-60. Ligeledes var det hans fortjeneste, via forhandlinger med Carlsbergfondet, at RC i 1956 kunne rykke ind i Valby på Bjerregårdsvej nr. 5 (nu nedrevet) hvor DASK blev bygget med Bent Scharøe Petersen som chefingeniør og officielt indviet den 13. februar 1958.



Figure 4: "Lille p": Professor, dr. phil. Richard Petersen (1894-1968).

Linket <http://akira.ruc.dk/~hbh/DASK/DASK1.html> fører til en fremragende artikel, "DASK - en 1. generations computer", skrevet af H.B. Hansen, i min tid (1958-1964) ved RC et skattet medlem af medarbejderstabben, senere professor ved RUC, Roskilde Universitet. I de følgende to afsnit redegøres ad verbum for det dansk-svenske samarbejde: "Det lettere humoristiske navn Dask vakte nogen betænkelighed i bestyrelsen, men blev dog aksepteret,

måske fordi det passede godt sammen med navnet på den svenske maskine Besk, der var nogle år forud for Dask. Besk står for "Binär Elektronisk Sekvens Kalkulator" mens Dask betyder "Dansk Aritmetisk Sekvens Kalkulator". Det var oprindelig meningen at Dask skulle være en kopi af Besk, og allerede i 1952 opnåede man tilsagn fra det svenske Matematikmaskinnämnden om at få stillet tegninger og know-how til rådighed. Chefdesigneren for Dask, civilingeniør Bent Scharøe Petersen, havde allerede i sit eksamensprojekt fra 1953 vist interesse for digitalteknik. Han blev headhuntet af lille p, og blev sendt til Stockholm for at lære noget af svenskerne. I maj 1954 blev de første kurser i kodning for Besk afholdt, og her deltog fra dansk side bl.a. Scharøe og en vis beregner fra Københavns Telefon A/S, Niels Ivar Bech, der blev den første og - kan man vist uden overdrivelse sige - mest dynamiske leder af Regnecentralen.



Figure 5: Niels Ivar Bech (1920-1975).

Set i lyset af den hastige udvikling af teknologien der skete netop i disse år, blev det ret hurtigt klart at der kunne opnås forbedringer ved at videreudvikle Dask i forhold til Besk. Dask blev derfor ikke en kopi af Besk, men en helt selvstændig konstruktion. Dog blev det besluttet at Dask skulle være kompatibel med en anden svensk maskine, SMIL i Lund, da man mente at så var hele behovet for regnekapacitet i Øresundsregionen dækket adskillige årtier fremover (!)".

DASK, nu med navnet forklaret som Dansk Aritmetisk Sekvens Kalkulator, hvis rester kan beses på Danmarks tekniske Museum, vejede 3,5 ton og

opfyldte med tilbehør to stuer i den tidligere herskabsbolig. Gulvet måtte forstærkes med ekstra stolper i kælderen, der rummede et omfattende kølings- og ventilationsanlæg, hvor kølingen foregik direkte med vand fra et lokalt vandværk. Strømforsyningens kviksølvensrettere lyste blåt ud i haven og foruroligede naboeerne, der klagede over "en prikken i huden" ved passage af ejendommen. Andre nøgletal: effektforbrug ca. 20 kW, 17.857 aritmetiske operationer pr. sekund, 1.024 ord à 40 bits i arbejdslageret og 8 gange så meget fordelt på to tromlelagre. Nutidens datafolk med deres flade laptops og ganske andre nøgletal, vil vægge sig ved at tro at det overhovedet var muligt at lave det, der rent faktisk blev gjort på DASK.

Naturligvis blev der ofte skrevet om RC i vores nyhedsmedier og Bo Bojesen glædede Politiken-læsere med tegninger af det elektroniske monster. DASK blev dog særligt kendt i den bredere offentlighed ved sin medvirken ved folketingsvalget den 15. november 1960, hvor en primitiv datatransmission mellem Bjerregårdsvej 5 og Radiohuset gjorde det muligt løbende at leve prognoser over valgets endelige resultat til radiolyttere og TV-seere.



Figure 6: RC-medarbejder J. Krarup ved folketingsvalget den 15. november 1960.

Efterfølgeren Gier blev skabt i forbilledligt samarbejde mellem Geodætisk Institut og RC og kunne præsenteres ved en kongres allerede i 1960. Med elektronrør udskiftet med transistorer var Gier af omfang kun som et stort klædeskab og blev anset som den tids mest fremragende computer af den størrelse. Et stort antal blev produceret, fra 1963 i en tidligere kommuneskole i Præstø, og en halv snes stykker var i 1965 taget i brug ved danske universiteter og forskningsinstitutter. Dertil kom en betydelig eksport til en lang række lande, fortrinsvis i Østeuropa.

Polyteknisk Læreanstalt blev grundlagt i 1829 af H.C. Ørsted og blev forløberen for Danmarks tekniske Højskole (DtH) senere kaldet Danmarks Tekniske Universitet (DTU), der efter udflytningen fra København i dag kan findes på en nedlagt flyveplads på Lundtoftesletten tæt ved Helsingør-motorvejen.

Der næredes de største forventninger til samarbejdet mellem RC og DTU. Eksempelvis havde DTU-studenter siden 1959 benyttet DASK til deres eksamensarbejder, og i foråret 1964 installeredes en GIER på DTU. Der blev afholdt kurser, og Bygning 305 var markeret med Regnecentralen på arkitektægteparret Koppels originale tegninger over Lundtoftebyggeriet.

Men selv efter diverse aftaleudkast og langvarige forhandlinger mellem de implicerede parter, herunder flere regeringsmedlemmer, endte historien brat, da IBM omkring 1963 tilbød at donere en IBM 7090 til 20 millioner kr. Denne monstrøse sag på 200 kvm blev i 1965 installeret i bygning 305, der i samme forbindelse blev omdøbt til NEUCC, Northern Europe University Computing Center.

Som H.B. Hansen i sin artikel allerede har påpeget, bør intet skrives om RC uden nævnelse af Niels Ivar Bech (1920-1975) der i 1957 tiltrådte som direktør for RC. Bech var oprindelig matematikstuderende, blev senere skolelærer med disciplinære problemer som følge af en let stammen, skiftede til ansættelse som beregner ved Aktuarkontoret, KTAS, og nåede endelig karrièrens højdepunkt som RCs karismatiske leder.

Bechs visioner om computere og deres brug var langt forud for deres tid. Og skuffelsen over det videre forløb var ubærligt, da inkompentence og kortsynede beslutningstagere i den daværende regering lod sig lokke af en hurtig gevinst. Modtagelsen af IBM-maskinen blev en katastrofal afflvinning af et unikt forskningsmiljø omkring RC, skabt under Bechs lederskab, hvor forskningen vandt verdensanerkendelse og væsentlige dele af grunden blev støbt til det fag, der i dag kendes som datalogi. Perioden 1958-64 blev senere kendt som RCs gyldne år. Derefter spredtes medarbejderne; Peter Naur (1928-2016) blev i 1969 Danmarks første professor i datalogi ved oprettelsen året efter af Datalogisk Institut, Københavns Universitet, og i 2005 tildelt The Turing Award, datalogiens Nobelpris. Syv andre sluttede deres karrierer som professorer ved danske universiteter og højere læreranstalter, og en enkelt fik sit professorat i USA.

Har Per Gjerlov godkendt Allerød Nyts fødselsdagsomtale og dermed påstanden om IBM's

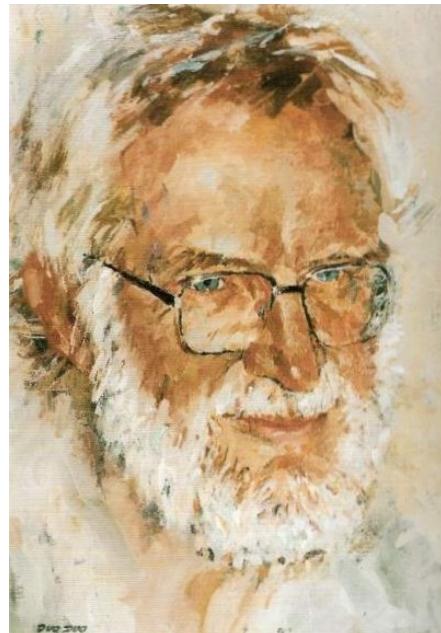


Figure 7: Peter Naur (1928-2016). Malet i 1995 af Duo Duo Zhuang.

7090 som Danmarks første computer, eller har forfatteren Kristina Pihl ikke uden søgning i ældre kilder haft mulighed for at verificere oplysningen?

Jeg er aldeles klar over, hvem den nu 91-årige Per Gjerlov er! Vi udviklede et godt venskab under sergeantuddannelsen ved Artilleriets Befalingsmands Skole (ABS, Ringsted) i 1955 og mødtes senere på RC i forbindelse med udviklingen af programmeringssproget Algol 60. I årene fra 1958 blev der i øvrigt afholdt flere møder mellem medarbejdere fra hhv. RC og IBM. Udviklingen begge steder blev fulgt tæt; den ene hånd vidste, hvad den anden gjorde.

Per Gjerlov har så sandelig kendt DASK. I en artikel fra 2015 om NEUCC skriver han om dilemmaet i 1963: "Therefore, late in 1963 serious negotiation started. At that time a plan existed to support Regnecentralen, the Danish Computing Center. Regnecentralen had, as a government supported institution, built the vintage computer DASK, and had constructed and sold a number of the more modern GIER computers. So Regnecentralen was to establish a large development office at the DTH campus with two GIER computers, and spare computer time could be used by the University. The dilemma was obvious: to support a budding Danish industry, or to give a major boost to use of computers in education and research by a donation from a large American company".

Svaret blæser ikke længere i vinden; tiden er

forlængst forpasset. Ak ja, sic transit...

Epilog

Ingen læser bør snyde sig for resten af H.B. Hansens artikel, hvori bl.a. DASK med diverse input-output udstyr beskrives med både stor detaljerigdom og humor. Hvor IBM baserede sine løsninger på hulkort faldt RCs valg på papirstrimler, og det sparsomme hulkortudstyr koblet til DASK var rent ud sagt miserabelt til større opgaver. Til gengæld byggedes strimmellæseren af fremragende kvalitet, kulminerende med RC 2000, hvorom H.B. fortæller følgende:

"Strimmellæseren var den navnkundige RC2000, der blev præsenteret i efteråret 1963, men havde været i drift på Dask og Gier et stykke tid forinden. Princippet i denne strimmellæser var at fremføringen af stimlen ikke skulle starte og stoppe på hvert enkelt tegn, men at der blev læst tegn ind i en elektronisk buffer, hvis fyldningsgrad styrede læsehastigheden. Tophastigheden kunne herved sættes op til 2000 tegn pr. sekund, hvilket svarede til en mekanisk fremføringshastighed af strimlen på 18 km i timen. Det var faktisk sådan at strimlerne stod vandret ud fra læseren og blev opfanget i en plasticspand, der blev anbragt i en afstand af 2 til 3 meter fra læseren.

Der blev gjort forsøg på at patentere RC2000, men det blev afvist med den begrundelse at princippet var beskrevet som eksempel på automatisk styring i en elementær lærebog; her så man altså bort fra alle de geniale detaljer læseren er fuld af, bl.a. gevindskårne lyskanaler til reduktion af uønskede refleksler ved den fotoelektriske aflæsning af hullerne i strimlen, og meget mere. RC2000 blev en kommercial succes; der blev solgt ca. 1200 af dem fra 1963 til 1973."



Figure 8: Interview på DR2 den 13. februar 2018, DASKs 60-års fødselsdag.

Folketingsvalget den 15. november 1960. Det falder uden for denne artikels rammer at beskrive den hektiske stemning på RC op til og med denne dato, ejheller omfang og art af de problemer, der måtte løses undertiden med ultrakort varsel. Om alt dette må H.B. etter konsulteres.

H.B. har dog ikke omtalt højttaleren midt på kontrolbordet, der vistnok var koblet til "bit 40" i det aritmetiske register. Et lille klik kunne høres, når bit 40 skiftede fra 0 til 1 eller omvendt. Udførelsen af et program var således ledsaget af en følge af klik, og med lidt træning kunne man nøje følge et helt programforløb fra start til slut. Det var også muligt at skrive et program, hvor følgen af klik blev til en tone af passende frekvens og med en vis varighed. Næste skridt var at komponere et stykke genkendelig musik! Jeg mindes en julefrokost, hvor RC-medarbejdere samles foran kontrolbordet og andægtigt lyttede til ... var det en lille stump af et af Johann Sebastian Bachs værker?

Før sin tiltrædelse som direktør for RC – Danmarks dårligst betalte efter eget sigende – var Bech ansat som beregner hos Arne Jensen ved KTAS. Arne blev i februar 1963 Danmarks første professor i Matematisk statistik og operationsanalyse ved et nyoprettet institut på DTU og her min speciale- og ph.d. vejleder. Hans vægtigste værker er alle skrevet på dansk og oversat til engelsk af Sword Translator, Mr. Poul Reppien. Det gælder også disputatsen fra 1954, hvor takken til medarbejdere også omfatter "... especially Computer Niels Ivar Bech".

Mange anekdoter er fortalt om Bech, og flere er gengivet i diverse tekster, herunder mindebogen fra 1976. Men vistnok ikke følgende: Hvem har nogensinde besøgt Bech i hans hjem eller vidst hvor det fandtes? Jeg mindes, at han i lange perioder beboede et værelse på et nærliggende hotel, hvorfra han ofte tog sporvognen op ad Valby bakke til RC. En dag ankom han efter at være faldet i snak med en medpassager på bagperronen. "Nå, hvad laver De så?", blev han spurgt. "Jeg er computer", svarede Bech. "Hvor morsomt, jeg er også konditor!"

I anledning af Peter Naurs 60-års fødselsdag skrev jeg i 1988 en artikel med titlen "Lille p", Bech og den unge himmelstormer", hvor sidstnævnte refererer til fødselaren, der oprindelig var astronom. Artiklen udkom i DATA, et ikke længere eksisterende tidsskrift. To afsnit er citeret her:

Hvor "Lille p's" liv udgjorde en harmonisk helhed blev Bechs i perioder kaotisk med større højder og større fald, som til sidst rev ham selv med. Modgangen og krisen, som satte ind omkring 1962-63,



Figure 9: *Et glimt af DASK.*

rummer elementer af stærk ekspansion, store forhåbninger og en betrængt økonomi, stillet over for offentlige myndigheders og institutioners ufattelige snæversyn og uforståenhed. Et forløb, som fremtvang en kommercialisering af RC, trak et skel mellem RC og de højere læreanstalter; som spredte kræfterne og svækkede udviklingen af dansk datalogi. En bitter historie om det tabte land - og afskedigelsen af Bech som direktør for RC.

Intetsteds er Bechs skæbne og personlighed smukkere sammenfattet end i den nekrolog, som bragtes i "Politiken" den 8. august 1975, senere genoptrykt i forordet til mindebogen, "Niels Ivar Bech – en epoke i edb-udviklingen i Danmark". Det hedder heri bl.a.: Niels Ivar Bechs død efter flere års kamp med personlige kriser og sygdom er egnet til at vække dyb eftertanke, også langt uden for den kreds der personligt oplevede ham som den geniale leder af mennesker. Hans skæbne er på det næjeste knyttet til troen på en selvstændig, stærk dansk og europæisk udvikling af datamatisk udstyr. Hans død markerer med næsten uhyggelig præcision denne tankes fallit. [...] Niels Ivar Bechs sind rummede dybder som selv dem der stod ham nær måtte finde gådefulde. Han, der var parat med enhver form for hjælp til sine medarbejdere, i stort og småt, var selv i dyb forstand uhjælpelig. Men dem der fik lov til at opleve ham i de gode år vil aldrig kunne glemme ham.

At være en del af RCs medarbejderstab i de gyldne år 1958-1964 blev afgørende for mit videre

karriereforløb. Særligt glædeligt var de livslange venskaber med flere, der fulgte i kølvandet. Taknemmelighedsgælden til især "Lille p", Bech og Peter Naur kan aldrig tilbagebetales,

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C. Thorhauge, Claus Thorhauge : link til "Regnecentralens gyldne år"

Video-præsentationer m.v. kan findes på internettet under Dansk Datahistorisk Forening, stiftet i 2002. Linket er vist her: <https://datamuseum.dk/w/index.php?title=&oldid=26430>

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Applications of Optimization 2021

by João Fonseca and David Koza



Monday, October 4th 2021, marked the return of Applications of Optimization (AOO). After cancellation in 2020 and postponement in early 2021 due to Covid-19, we were finally able to hold our estimated one-day conference. Both academic and professional OR affiliates were able to network and attend interesting talks physically again, and it felt so much better than the virtual conferences some of us may have attended lately. Once again, we used the excellent and central facilities at Industriens Hus. We were supported by a broad range of companies - Gurobi, Mosek, Ørsted, and Sealytics – which also delivered short-and-crisp 5 minutes pitches between the talks, on how and why they use optimization.



The panel of speakers was diverse and complete, including academics and practitioners. After the (much needed) morning coffee and some (also much needed) networking and socializing, Michael Lindahl

was our first speaker. The VP of Analytics at Portchain treated us with an excellent walk-through of how Portchain use Operations Research and AI to reduce operational complexity at container terminals and to optimize planning. Next up was Ida Græsted Jensen, partner at the Energy Modelling Lab, a consultancy that offers advice and services in energy systems modeling. She gave a brilliant overview of how complex these models are and what can be done to actually solve them in practice.



Lunch was served and some more networking time was on the menu. It definitely felt great to see familiar faces in real life again, to get to know new members in the OR community, catch up, and suddenly, when you look at your watch, Katherine Dykes is up on the stage. The Head of Systems Engineering & Optimization at DTU Wind Energy took us by the hand to see the remarkable work that the group has accomplished in the field of wind optimization and applications of renewable energy. After that, it was time for shopping and IKEA was the place to go. Henrik Carøe Bylling, Senior Data Scientist at the Swedish giant, told us everything about IKEA's efforts in using optimization and data science for supply chain and fulfillment optimization, in an era where e-commerce puts a huge pressure on better planning and decision-making. Our final speaker of the day was Niels-Christian Fink Bagger, Data Scientist at Novo Nordisk. To the extent that confidentiality allowed, he showed us how Novo Nordisk uses optimization to improve planning at one of the manufacturing facilities owned by the company, and presented us some of the everyday challenges of applying OR in a manufacturing environment.

We ran a survey at the end of the conference and we will leave you with some key results here:

- most people attended AOO for networking reasons (71%), followed by the talks (50% - multiple options were possible)
- 87% of the attendants found the sponsor pitches interesting
- a whopping 100% said that the conference fulfilled their expectations – thank you!

David Franz Koza is board member of DORS and organizer of AOO2021. He holds a PhD in Operations Research from the Technical University of Denmark and works as an Operations Research Engineer for Vattenfall, in Offshore Wind. David is passionate about turning data into knowledge, and using math, models and algorithms for better decision making.



We were very happy to see so many of you and we look forward to next time. We had to wait a long time for this one after the last AOO conference in 2019, so to make up for the long waiting time, let's shorten the distance to the next AOO: see you all in May for AOO 2022!

Joao Fonseca is a Senior Optimization Specialist at Portchain, working with optimization problems arising in container terminals. He holds a PhD in Operations Research from DTU on the topic of Timetable Integration in Public Transport Planning, defended in 2019. Since 2020, Joao is also a board member of DORS and co-organized AOO2021, and he is now the new Editor of ORbit.



Metaheuristics in research – a lesson (for me)

by Michael Patriksson

Metaheuristics for a variety of mathematical programming problems was something that I knew nothing about of, before I was contacted by a few Iranian scholars at the beginning of the 2010s, looking for help to be able to publish in reputable journals. My first hunch – as an avid mathematical programming scholar – was that this must be a scam. How did they find me? What is this weird topic, and why on Earth do they accept inferior solutions?? Anyway, I took a chance, and I started to work with them, and over a few years I wrote quite a few journal articles on metaheuristics, eventually also with other research groups, but mainly Iranians, mostly geared to practical logistics problems. In the bargain I became aware that this is indeed a nice niche, once I accepted trying to come as close as possible to the ideal place, but with limited resources, and limited theory. This article can be seen as a short diary from those years.

My first sight of a metaheuristic did not impress me, but then again, I was not aware what it was. Being immersed in the mathematical programming “speak” since 1988 – the year I became a PhD student in mathematical optimization at the department of Mathematics at Linköping University, Sweden – I was blind to other worlds of tools than that. And it was a bit of a shock to learn that – more or less –, everyone who contacted me from the Middle East during a few years around 2013–2020, had something up their sleeve – a metaheuristic that they wanted me to take an interest in! My initial instinct told me to stay away – but I got intrigued, especially because their problem settings often were based on some form of a logistics question – and I cannot hide that my most cited paper is one that deals with vehicles and congestion – which does ties in with what they did. So, they had me, as they say, already at the start!

I still prefer mathematical optimization tools, as I especially like the theory bit, but also as I have contributed to general optimality conditions together with my former PhD advisor prof. Torbjörn Larsson in the paper “Global optimality conditions for discrete and non-convex optimization – with applications to Lagrangian heuristics and column generation”, Operations Research, vol. 54, no. 3 (2006), pp. 436–453, which nails down the law on what global optimality means.

But I eventually could see the meaning and purpose of quick-and-dirty principles, as several logistics problems are not only multidimensional, but also need to be solved fast – as the customer needs it – preferably yesterday! – and hence heuristics have a clear role to play, either as a starting point to exact solvers, or even stand-alone ones, depending how quickly the result is needed. In fact, I was once enrolled to take part in a bachelor project with the focus on creating simple rules for employee planning in supermarkets, and that was a gas!

So to re-iterate: my first impression was quite wrong: those who needed advise on tools had a very clear vision on how the tool should work – at least more than me.



Michael Patriksson is a professor in applied mathematics since 2004 at Chalmers University of Technology, specialising in mathematical optimisation. He was the coordinator and main author of the monograph "An Introduction to Continuous Optimization", which is the main course book in the basic course on mathematical optimisation, now in its 3rd edition. He has also written the monograph The Traffic assignment Problem, first issued by VSP in 1994, and now also at Dover since 2015.

The Multi-Class Constrained Bin Packing Problem

by Baptiste Coutton, Stefan Guericke, Klaus Holst, Martin Philip Kidd and Dario Pacino

Global freight transportation relies heavily on the use of standardized containers. To reduce the costs and environmental footprint of their operations, logistics companies seek to minimize the number of them they use. But this objective is sometimes challenged by cargo owners who impose rules on how the cargo items can be mixed together inside the containers. This work studies a container loading problem under a specific formulation of cargo mixing constraints that arises in the shipping industry. A number of heuristics and an Adaptive Large Neighbourhood Search metaheuristic framework are developed and used on existing and newly generated instances with up to 1000 cargo items and 600 containers. Comparison with a mathematical solver shows that our algorithms have the potential to yield quality solutions in up to 200 seconds.

this approach, goods are first transported from their shippers to a warehouse where they are stored with other goods prior to being containerized. Larger cargo availability increases the likelihood of filling containers close to full capacity. This approach is particularly useful when the shippers do not produce shipments large enough to fill a full container and is used by, for example, large retailers that receive their cargo from various, geographically scattered small factories.

However, even when cargo consolidation is practiced, obstacles to the full utilization of containers remain. One of them stems from the requirements of some cargo owners (also called *consignees*). Some might be justified by practical considerations: for instance, a consignee might request at most two orders and at most three types of goods per container to ease dispatching when the container is unloaded upon arrival at destination.

The problem we want to solve is a generalization of the latter, which to the best of our knowledge has only been addressed once in the literature [1]. Our contributions are the implementation of new (meta-)heuristics methodologies for its resolution and the generation of new larger, more complex and randomized benchmark instances.

Introduction

Since their introduction in the mid-twentieth century, standardized containers have been the backbone of global trade and one of the pillars of globalization. In 2021, 52% of seaborne trade was containerized [9]. Container throughput represented an amount of 811.2 million twenty-foot equivalent units (TEUs) in 2019, a 1.9% increase compared to 2018 [8]. The transported commodities are diverse, and the focus of this study is on non-refrigerated containers transporting boxes of light manufactured goods.

A key objective for freight distribution planners is to minimize the number of containers needed for each transport operation, as using an extra container incurs an additional cost for renting it and/or for its transportation. As a consequence, the planners seek to maximize the filling rate of the containers they are using so that they need as few as possible. Furthermore, increasing the filling rate of containers is directly related to efficiency gains and as a consequence to a reduction of greenhouse gases emissions. However, in 2018 it was estimated that containers were filled at only 64.8% of their capacity [4]. This suggests there is still room for improvement in the global container load planning practices. One opportunity would be relying further on cargo consolidation prior to the loading phase. With

The Multi-Class Constrained Bin Packing Problem

The proposed formulation is similar to the one presented in [1]. In this problem, we are given a set of items (boxes) I to be loaded in a set of containers J . Each item $i \in I$ has a volume v_i and each container $j \in J$ has a total volume capacity V_j (the problem is therefore one-dimensional with variable bin sizes). We assume that the items are light enough so that we can never reach the weight capacity of any container, which removes the need for constraints on that aspect. The cost of using container j is denoted as c_j .

All items have an associated set of attributes A (also called classes in the literature). All items have the same attributes yet can differ by the value they are taking for each attribute. The set of values that are taken among all the items for attribute $a \in A$ is labeled C_a . For an attribute $a \in A$ and a related value $c \in C_a$, the set of items that take the value c for attribute a is called P_c . Each container has a certain amount of distinct values that it can fit for a given attribute $a \in A$.

This upper bound is independent of the container and is referred to as d_a . We introduce the following three sets of binary variables: x_{ij} equal to 1 if item i is loaded into container j , 0 otherwise, y_j equal to 1 if container j is used, 0 otherwise and w_{cj} equal to 1 if an item with value c for attribute a is present in container j , 0 otherwise.

The problem is therefore formulated as follows:

$$\min \sum_{j \in J} c_j y_j \quad (2)$$

subject to:

$$\sum_{j \in J} x_{ij} = 1 \quad \forall i \in I \quad (3)$$

$$\sum_{i \in I} v_i x_{ij} \leq V_j y_j \quad \forall j \in J \quad (4)$$

$$\sum_{i \in P_c} x_{ij} \leq |P_c| w_{cj} \quad \forall a \in A, c \in C_a, j \in J \quad (5)$$

$$\sum_{c \in C_a} w_{cj} \leq d_a \quad \forall a \in A, j \in J \quad (6)$$

$$x_{ij}, w_{cj}, y_j \in \{0, 1\} \quad \forall i \in I, j \in J, a \in A, c \in C_a \quad (7)$$

The objective function (2) to minimize is the total cost of all containers used. Constraints (3) ensure that each item is loaded inside a container. Constraints (4) enforce that the volume capacity of each container is respected. Constraints (5) are used to activate the w variables. Constraints (6) guarantee that the upper bounds on the different attribute values are respected in each container and for each attribute. Finally, the domain definition constraints are represented by (7).

The only work about the multi-attribute (or multi-class) case proposed a resolution based on a mathematical solver and a deterministic first-fit decreasing algorithm [1]. Additionally, several studies were conducted about the one-class formulation. Polynomial time approximations of the problem first emerged [7], before the first industrial application was solved using a branch-and-price algorithm [5, 2], namely in the context of printing Tetra-bricks on printing rolls for the beverage industry. Another application was found in video-on-demand and was solved by several approximation algorithms in offline and online versions [10], and an extensive bounds estimation was conducted [3].

Solution approach and results

The problem formulation was first implemented using the mathematical solver Gurobi with a time limit of 3600 seconds, but results from [1] suggested the possibility of getting acceptable results in much

shorter time. This justified the evaluation of alternative heuristics that could enhance the performance of the first-fit-decreasing algorithm. We decided to develop a methodology based on the Adaptive Large Neighbourhood Search (ALNS) metaheuristic framework [6]. Several destroy and repair methods were implemented. Destroy methods include for example the removal of containers with a filling rate below a given threshold plus some additional random containers. Another method allows to "re-open" containers with low filling rates for which not all rules upper bounds have been reached, but removes the low-filled where all upper bounds have been reached. Repair methods include for example a randomized variant of the first-fit-decreasing heuristic from [1], a best-fit-decreasing heuristic and methods that seek to load "similar" items together.

The scarcity of benchmark instances for the multi-class formulation of the problem was an argument in favor of the creation of new ones for experiments. The instances from [1] were re-used and each include 100 items. Three sets of larger instances (200 to 1000 items) with up to 5 attributes were also generated. The sets differ by the volume distribution of the items: one has mostly small items, another mostly large items and the last one a mix of small and large items.

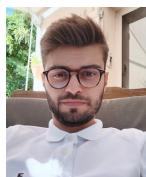
Preliminary results show that our algorithm found, in no more than 200 seconds, better solutions than Gurobi's. We observed an average improvement of 4% for the mixed-sized items and 17% for the small items instance sets. For the large items instances and the benchmark instances from [1], the average relative improvement was only less than 1%. However, for those sets, the average optimality gap (between best integer solution and best lower bound) of Gurobi was of less than 10%, which suggests that it is difficult to improve the best integer solution. For the small and heterogeneous instance sets, this average optimality gap was of 17% and 60% respectively.

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EURO 2022

We have the great pleasure of inviting you to take part in the 32nd EURO Conference to be organized in Espoo, Finland on 3-6 July, 2022.

The Scientific and Organization Committees, chaired by Dolores Romero Morales and Antti Punkka, along with Juuso Liesiö and Eeva Vilkkumaa, are preparing a conference to remember. EURO 32nd Conference will be an excellent opportunity for the OR community to get together again in a pleasant atmosphere, and we are looking forward to meeting you in Espoo next summer!



CALL FOR PAPERS AND SESSIONS

Researchers, academics, practitioners, and students interested in any branch of Operational Research, mathematical modelling or economic analysis are invited to submit abstracts or organize sessions. Invited and contributed papers will be organized in parallel sessions. In general, sessions are part of the Conference streams, and streams are grouped in different areas. The list of areas and streams is available at <https://euro2022espoo.com/conference-programme/areas-and-streams/>. No participant can present more than one paper at the Conference. Researchers who wish to organize a stream or an invited session or contribute with a paper within an invited session should contact a PC member of the corresponding area.

IMPORTANT DATES

- Abstract submission deadline: March 4, 2022
- Early registration deadline: March 25, 2022
- Author registration deadline: April 8, 2022

REGISTRATION FEES

- Regular: €385.00 (early); €513.00 (late)
- Student/Retired: €210.00 (early); €280.00 (late)
- Accompanying persons: €129.00

The regular/student registration fee includes:

- Admission to all sessions and the exhibition
- Conference materials
- Tea, coffee and lunches throughout the conference
- Admission to the Welcome Reception on Sunday and to the Farewell Party on Wednesday

The registration fee for an accompanying person covers the same except the admission to sessions and conference materials. Please note that the Conference Gala Dinner on Tuesday is not included in the registration fee.

CALL FOR EXHIBITORS

Parties interested in having a booth or exhibition area during the Conference are kindly requested to contact the EURO 2022 Conference Secretariat (Gráinne McQuaid: euro2022@abbey.ie).

We look forward to welcoming you to our great conference in Espoo!

For any further information, contact the EURO 2022 CONFERENCE SECRETARIAT:
c/o Abbey Conference & Events
· Phone: (+353) 1 648 6130
· Email: euro2022@abbey.ie

