**Bonus Episode: Dude, where's my parcel? with Ivona Gjeroska, Paula Fermín Cueto and Albert Solà Vilalta (Pi Day Special)(S02E03.14)**

**Not Another Science Podcast**

**March 14th, 2021**

<span style="background-color: #fce9bf">Introduction</span>

*Intro music starts, and fades out throughout the intro.*

[Helena Cornu] Welcome to this special episode of Not Another Science Podcast, I'm Helena.

[Tom Edwick] And I'm Tom.

[Helena] Today, March 14th, is pi day, and so we thought we'd bring you a special mathsy bonus episode. You might remember that on the last episode of season 1, we talked to Miguel Anjos and Lars Schewe from the University of Edinburgh School of Mathematics about their work on optimisation of energy systems. If I do say so myself, it was a fantastic episode, so if you haven't listened to it, then queue it up after this one.

[Tom] Miguel coached a team of students for the 2020 Advanced Interactive Multidimensional Modeling System's  Modeling and Optimization: Theory and Applications competition — ooh, that was a mouthful, anyway — and they agreed to chat to us about what problem they were set, and their experience of the competition. It was fascinating to hear how they tackled the challenge.

[Tom] Before we start, this podcast is sponsored by Greiner Bio-One, supplying laboratory, diagnostic and medical products to research institutions, higher education, the NHS and others across the UK. For details of the full product range, visit [www.gbo.com](http://www.gbo.com).
And now, on with the show!

*Cue the bongos.*

[Tom] So I guess we can start with some introductions. So, whoever wants to go first, you can tell us who you are and what you do.

[Ivona Gjeroska]I'm Ivona, I'm a PhD student, just started my third year now. I'm working on a specific project in operational research and optimisation.

[Paula Fermín Cueto] I'm Paula, I'm also a PhD student in optimisation and finishing my first year, and I'm working on a scheduling problem that arises in aviation.

[Albert Solà Vilalta] Hello, I'm Albert, I'm also a PhD student in optimisation and operational research, and more specifically, I'm working on a problem in the energy system.

[Helena] So we heard about you because you won the AIMMS-MOPTA competition. Could you tell us a bit about it?

[Paula] This is a competition that runs every year, it's always some kind of optimisation problem. This year, or the year we participated, it was a vehicle routing problem, which is similar to what Ivona does I think. For us it was something new.

I think Ivona and I signed up even before we knew what the problem would be about, we knew we wanted to participate, and then we got Albert involved because it was a… We could get three people involved in the team and we wanted a third person — it was going to be so much work!

[Tom] And did you guys, did you all know each other beforehand, or how did the team come together?

[Ivona] Me and Paula did our MSc together, so we know each other from then. And then Paula went into industry for a year, so I started my PhD before that, and then she joined a year later, and pretty much as soon as she joined, as soon as she started her PhD really, we learnt about this project and we basically started working on it right away. And yeah, so the supervisor

that was our supervisor for this project, is actually Albert's
PhD supervisor, which is how we came across Albert because he
suggested him. So yeah, it worked out great!

[Albert] On my side, one day Paula tells me: "Do you want to
join us?" And then, it was a problem that I knew nothing about,
really nothing, and then I thought: "Well, it's a good chance,"
and then I said: "Okay, I'll join you."

[Paula] Ivona knew a lot about the problem, I knew some things
about the problem, and it was new to Albert. It was a good mix.

*They laugh*

[Helena] I watched your video, which by the way, was really
cool. I understood most of it and then you lost me in the
details, but could you tell us for the podcast, a little bit
what the problem is about and also how you went about solving
it?

[Albert] I like to describe the problem as the Amazon problem.
So you can imagine you are Amazon, and you want to establish
yourself in a new country, and you know you have some peoples to
serve, so you have to serve them. And then you first have to
decide where you wanna put your depots — you'll need some
depots, right? So you have to decide where you want to put the
depots, then decide how many vehicles and people working you
want in each depot, and then eventually each day decide how you
route the vehicles.

[Paula] For the way we approached the project, I think what we
did was a bit different from what other teams did. I think
that's something that made us stand out a bit, it's the fact
that we tried to treat it as a real-world consulting problem
rather than a research problem, so even though we didn't know
anything about this hypothetical company, we tried to treat it
as a real company with real problems, so we tried to think
strategically and we took the big problem that Albert just
described and tried to break it down into different levels. We
thought, well the… deciding where the depots should be placed is
kind of a strategic problem, it's something you only decide

once, you don't want to build a depot every year, so we'll do that separately. And then we will decide the vehicles in a similar way, and then we have a separate problem for deciding the routings every day, so we kind of broke it down into manageable problems. That made sense for the company, and also made our lives easier because then it would be easier to solve it.

[Tom] So if you were to describe how you solved it, to people who have no idea about maths and optimisation, basically me and Helena… *Laughs*. In simple terms, how would you describe that, do you think? Ivona, if you want to jump on that one.

[Ivona] It was a very good situation, that we had me, who is actually working on the topic as part of my PhD, so this was obviously a slightly different application, but it's the same topic, then Paula, who's worked in industry and also knows what clients want and what needs to be done from the industry perspective of it, and then Albert who also looked at the problem from sort of outside the problem and said: "Okay, this is actually what we should do." So it was, I think a good combination of the three of us, that we managed to put our own specific inputs rather than all of us just going at it from a research perspective.

So the way we started was… obviously we started from a slightly theoretical aspect just so we can understand the problem better. We started with formulating the problem, and looking at… As I said, from a theoretical aspect, looking at what is actually challenging to solve, and then finding alternative ways to solve those challenging things in the problem.

And then, we went on, as Paula said, into breaking up the problem slightly, and then trying to solve in part in part. So, as Albert said before, we had this problem of basically just a map of a lot of customers, and then in that map we had to locate our depots, so that was our first problem, was: where are we going to locate the depots? So that was a completely different problem that we were trying to solve, not taking into account the delivery or anything like that, so basically where do we place these depots.

So then we started a different problem after we had the depots placed as: how many vehicles do we actually put in each one of these depots? And then the last problem was, okay, so now that we have the vehicles, and we have the depots: who do we serve first? What do our routes look like, basically? And what we had at our disposal were datasets, that we had from previous years, what people's demands were in previous years, and then we had to do some statistical analysis to see what the people's demands are going to be this year based on what they were in the past two years.

So that's in a nutshell what we had to do, but that took three months. *She laughs*

[Helena] I mean it's… It sounds fairly simple when you present it, like: "Oh, we just had to figure out where to put these things." But there are so many different informations to take into account, and I think I read that they actually didn't include a bunch of data in order to make it more realistic, is that correct?

[Paula] The fact that they gave us a lot of data was, yeah, made it look like a real problem. We were given all the data from 2018, the demand of the customers, and also 2019, but we were not supposed to use 2019 at all. This was sort of our test dataset, that was just there for us to test how good our models were.

I don't think that was the most challenging part of the problem, I think the challenging part of the problem was to find algorithms that could give us a solution for such a big problem. We started with 1000 customers, and as Ivona knows very well, these vehicle routing problems usually come with 20, 30 customers. So that was one of the biggest challenges: to find a trade-off between time it takes to find a solution and the quality of a solution.

So we had to balance two different approaches. So in optimisation we normally use either an exact approach, that usually takes a long time but gives us the best possible

solution, and a heuristic approach, which gives us a good enough solution fairly quickly. So depending on the problem, on the day we were trying to solve how many customers there were, we would use one or the other. So we sort of developed two algorithms in parallel, and then decided which one we used.

[Tom] Obviously, because of the lockdown situation, I guess that must have made it difficult to coordinate and collaborate on the project.

[Albert] I'll start with the positive side, maybe. So on the positive side, I found it a very fun activity to do during lockdown. So it was far more interesting than doing anything else, so that was good. And of course, I don't think it's the same as being able to meet in person and discuss face to face and so on, we could do that I think for two weeks. Did we have two meetings in person, or something like that?

[Ivona] Yep.

[Paula] But they were the two crucial weeks at the beginning, where we did all the brainstorming, so that was good.

[Albert] Yes. And then I think we got used to Teams, and Zoom, and the collaborative tools we had in hand.

[Ivona] Yeah, I remember that the… On the second week that we started working on this, we got together, we spent a good few hours just brainstorming and writing down the theoretical aspects of the problem, and after that we went to the pub, and we said: "Okay, so you know, we're going to have a couple of pints, and then see you guys on Monday, we're going to continue working," and then on Sunday, lockdown started, and we didn't see each other again for three months.

*They laugh*

[Paula] More like six months, actually!

[Ivona] Yeah, yeah actually, because… Yeah, so it was very unexpected. Basically we just said: "Okay, see you Monday!" and then, it just never happened.

[Paula] Yeah, yeah. Organisation skills were key, in this project, to make sure we had good communication, we gave each other visibility of what we were doing at all times, and things like that.

[Helena] And then, we just wanted to ask you: What's next for you? What are your plans, personally, with this project? Did that help you with what you want to do?

[Ivona] So actually, at the presentation of this project, we had an editor of a journal present, and then we wrote a paper on this topic, and actually just today, we got an email this morning that the paper's been approved, so…

[Tom] Oh, amazing!

[Helena] Amazing!

[Tom] Congrats, that's so cool.

[Ivona] Thank you. It's the first paper on this… It's also very exciting for me, because it's a very similar topic to my research, but it's the first paper published for me.

[Tom] Is that the first paper that you guys have had published, or is this kind of an exciting new thing to happen to you guys?

[Paula] It's my second paper, I wrote my first paper with other colleagues from the University.

[Albert] Yeah, and it's my second paper as well, but the first one in this topic I knew nothing about.

[Helena] Yeah, that's quite a… I was going to say, "I knew nothing about this but I wrote a paper about it," that is… *She laughs*

[Albert] Well…

[Helena] In three months!

[Albert] I mean, I didn't do that alone, right?

[Helena] Of course, yeah.

[Albert] I had very good collaborators.

[Tom] I really enjoyed your team name but I was confused about what the "NP" meant.

[Paula] Ooh, that's a very difficult thing to define in simple terms.

[Ivona] It has, okay… It's a very well known term in the optimisation and operational research community, because it's something that gives us a lot of problems, basically. *She laughs.* It has to do with the complexity of the problem. So np hard basically means that it's impossible to solve to us.

*They laugh*

[Paula] Does it mean that when the problem grows in size, the complexity and the time to solve it grows even faster?

[Albert] It's related to what Paula said before about… We had two methods to apply, so an exact solution method, and a heuristic. So when for small instances, you can solve it exactly, because it's small enough, but then as it grows you have to do something else because actually, it's np hard.

[Tom] That brings whole new meaning, I love it.

[Ivona] Yeah, we were very proud of our team name, actually.

*They laugh.*

[Helena] Well especially because I think you were the only ones who went for a kind of actually punny name. I think one of them

was "Go Blue" or something? Which I'm assuming is their University colours or something? And I was like: "That's not punny enough for me."

*They laugh*

[Helena] I think that's kind of all the questions we wanted to ask you, but is there anything else that you'd like to tell us about the competition, or that you'd like to add?

[Paula] I would suggest to all PhD students or Masters students that would consider participating in a competition like this, personally I can't recommend it enough. I think it's a great experience to learn something new, because in our PhDs we normally spend four years working on a very specific problem, so it's easy to become an expert in something very narrow, so this is a great opportunity to learn something different and to do some teamwork. PhD is normally a lot of individual work. So yes, if someone is considering doing something like this, go for it!

[Albert] And don't be scared of not knowing the topic, as long as you have the right colleagues, you can manage.

[Helena] Thank you guys so much, like… And also massive congratulations, I should have said this at the beginning, but oh my gosh, massive congratulations for winning this competition.

[Albert] Thank you!

[Ivona] Thank you!

[Paula] Thank you very much!

[Ivona] We spent so much time on it, we were glad we won, otherwise it would have been difficult to justify!

*They laugh*

Outro

*Outro music starts.*

[Tom] Massive thanks to Paula, Ivona and Albert for speaking to us about the competition — and massive congratulations again! If you want more details about the problem they were set and their solution, you can check out the recording of their presentation, and you can also read the paper they published in the Networks journal. We'll put links to those in the show notes. The three members of team NP Die Hard are all on LinkedIn, and we'll put those links in the show notes as well so that you can find out more about them.

[Helena] This podcast is brought to you by the Edinburgh University Science Magazine. In each episode we explore fascinating themes and ideas, talk to awesome researchers about their work, and find out about the science being done by our very own staff and students here at the University.

[Tom] If you have any feedback for us, or if you'd like to get in touch with a question or suggestion, you can reach us on our Facebook page, Edinburgh University Science Media, or at our twitter, @eusci, that's @e-u-s-c-i. You can also drop us an email at [eusci.podcast@gmail.com](mailto:eusci.podcast@gmail.com), and you can find the show notes and the latest issue of the magazine at eusci.org.uk. If you would like to be featured on the podcast, please get in touch, and keep an eye on our social media for more information.

[Helena] This episode was hosted by me, Helena Cornu, and my partner in crime, Tom Edwick. The podcast manager is Alix Bailie. The podcast logo was designed by EUSci chief editor, Apple Chew, and the awesome podcast episode art was designed by Heather Jones, our social media and marketing genius. The intro and outro themes are edited from music by Kevin McLeod.

[Tom] Thank you for listening, and until next time,

[Helena] Keep it science.

*Outro music ends*