Optimization Problems @ Ericsson
A Little About Myself

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Senior researcher @ Ericsson

2012
KTH
Master in Computer science

2018
KTH
PhD in CP + compiler technology

2018
Ericsson
Microkernels, compilers, constraint modeling
Founded in 1876

100,000+ employees

Sweden’s 3rd largest company

(by turnover, Statista 2022)
Enabling Communication For 140+ Years
Probably Your View of Mobile Telephony ...
A More Detailed View

Ericsson products

core network

authorization, bookkeeping, quota, billing, ...

radio unit

baseband unit

gateway

Internet

GET youtube.com

 Npgsql core network

authorization, bookkeeping, quota, billing, ...

radio unit

baseband unit

gateway

Internet

GET youtube.com

Npgsql
Organization

ERICSSON

sales

technicians

product development

research

Standards & Technology

S&T
Testbeds, proof-of-concepts, software research
Collaborates with product and research units
Optimization Problem #1: Site Hardware Dimensioning and Configuration

**Hardware selection**
- Which radios/basebands to use?
  - 100x different radio units to choose between
  - 10x different baseband units to choose between
  - Many compatibility rules

**Carrier allocation**
- Which carriers to allocate to which radios/basebands?
  - Many carrier support rules
  - Many capacity resource sets

**Diverse optimization goals**
- Minimize # units, maximize redundancy and/or uniformity, ...

* A carrier specifies protocol (e.g. GSM, 3G, 4G), frequency band, number of TX and RX antennas, etc.
Optimization Problem #2: Site Hardware Connectivity

Connectivity
- How many links to use? Which ports to connect?
  - Many link modes
  - Limited number of ports
  - Direct connections may be expensive

Radio cascading
- Which radios to cascade? How long? In what order?
  - Radio traffic accumulates with each radio in chain
    - Must not exceed link capacity

Deeply interconnected with problem #1
- Optimal solution requires #1 and #2 to be modeled as one
  - Search space explosion
Implementation

Two constraint models, written in **minizinc** (sacrifice **optimality** for **tractability**)

- Radio selection + carrier-to-radio allocation
  - **Constraints:** table, bin-packing, linear, ...
  - **4000+** lines of minizinc code
  - **147p** manual

- Baseband selection + carrier-to-baseband allocation + connectivity
  - **Constraints:** table, bin-packing, linear, ...
  - **5000+** lines of minizinc code
  - **166p** manual

- Solvers: **chuffed** and Google **OR tools**
Implementation

Product rule data stored in **Access** database
- 150+ tables
- 1,000x entries per table

Data extraction and conversion using **Python**

Efforts
- ~60% in features + correctness
- ~40% in model improvements
  - Redesign, implied constraints, breaking symmetries, dominance
Testing, Verification, and Debugging

- **Eyeballing** by domain experts
- **Regression** test cases with some decision variables **preset**
  - Positive: Solution found means **passed**
  - Negative: No solution found means **passed**
- **Search tree** analysis using **GecodeGIST**
  - Useful for **finding implied** constraints
- **UNSAT** analysis using **findMUS**
  - Gives smallest set of **conflicting constraints**
Difficulties with Applying CP in Industry

- Still **not common** practice
  - Team may need **convincing**
- **Hard** to find skilled model designers
  - Designers must also **learn** the problem domain
- Models must be **evolved** and **maintained** together with product team
- **Not clear** how to express objective function
- **Hard** to get **solution** in acceptable time frame
  - May need to **split** model
  - May need to do lots of **presolving**
Ericsson Wants YOU

Master thesis projects
- Automatic option pruning in UIs, explainability, proof-of-concepts, ...

Internships
- Model extensions, maintenance, benchmarking, model improvements, ...

Employment
- PDU NSV team is expanding

Contact fredrik.xh.nilsson@ericsson.com for more info
Summary

- Introduction to Ericsson and mobile telephony
- Two related optimization problems at Ericsson
  - Problem description
  - Implementation
  - Testing, verification, and debugging
- Difficulties with CP in industry
- Opportunities at Ericsson