

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



ERICSSON



Founded in **1876**

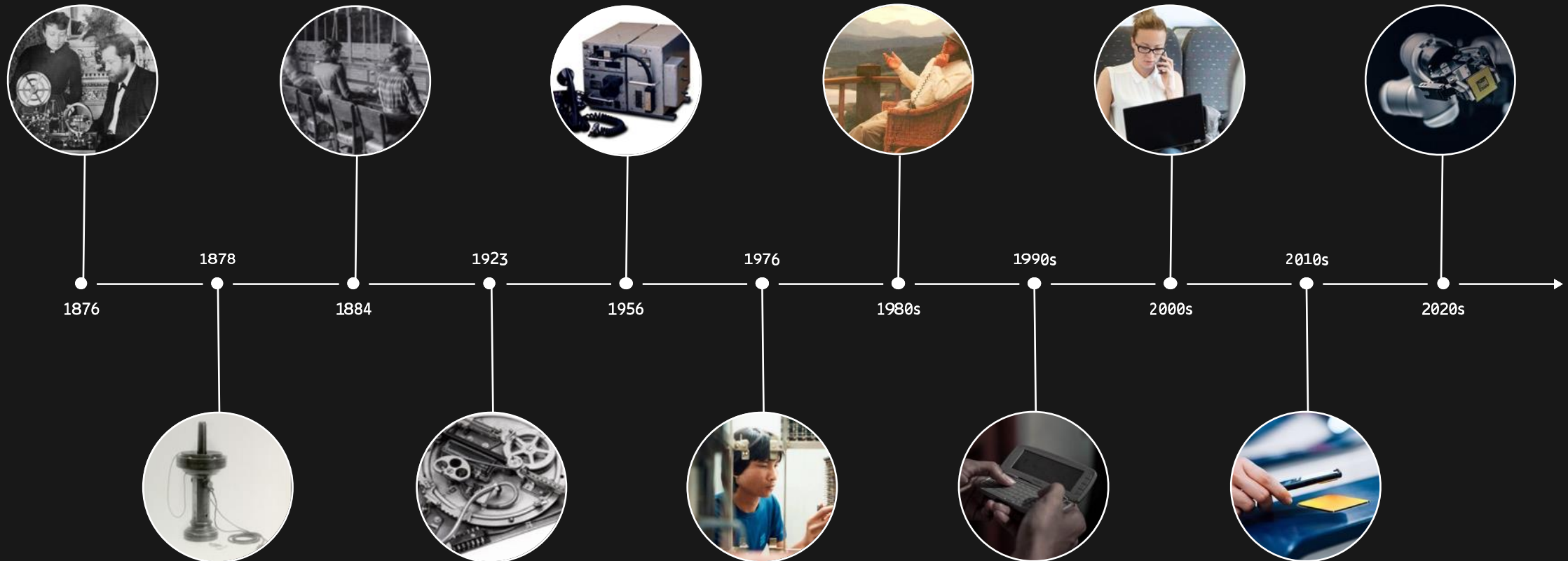


100,000+ employees

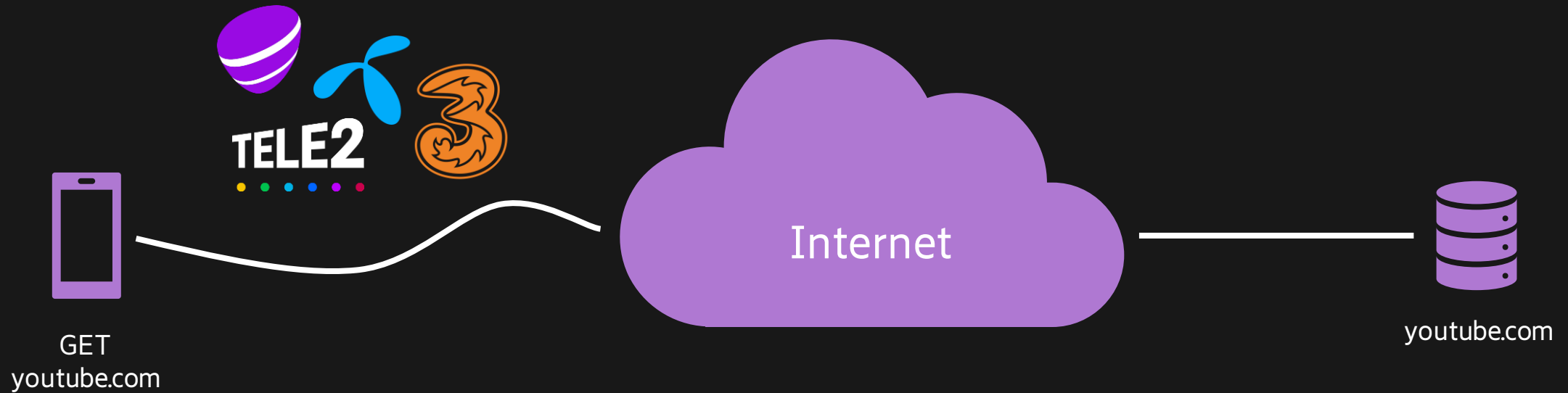


Sweden's **3rd** largest company
(by turnover, *Statista 2022*)

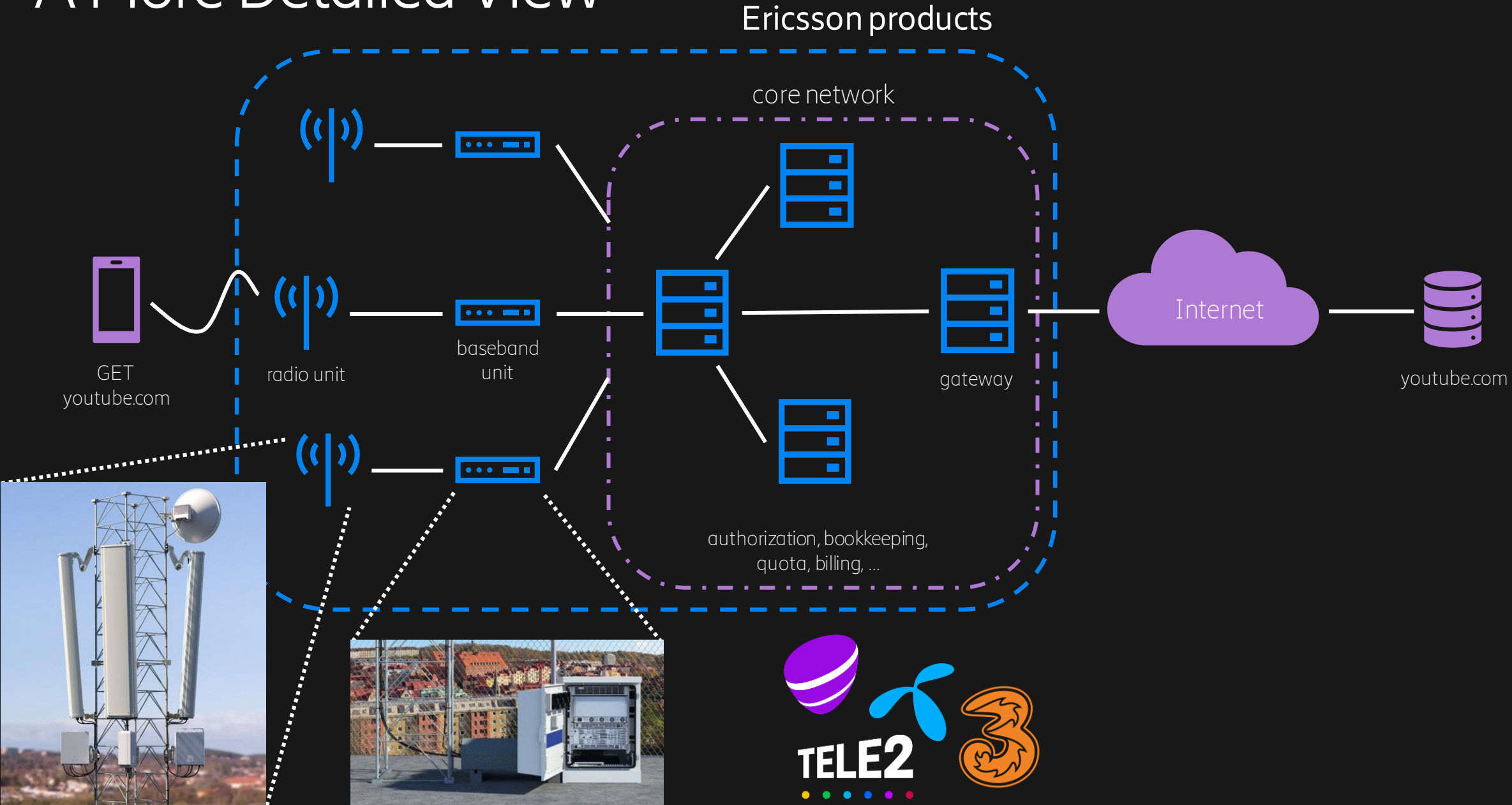
Enabling Communication For 140+ Years



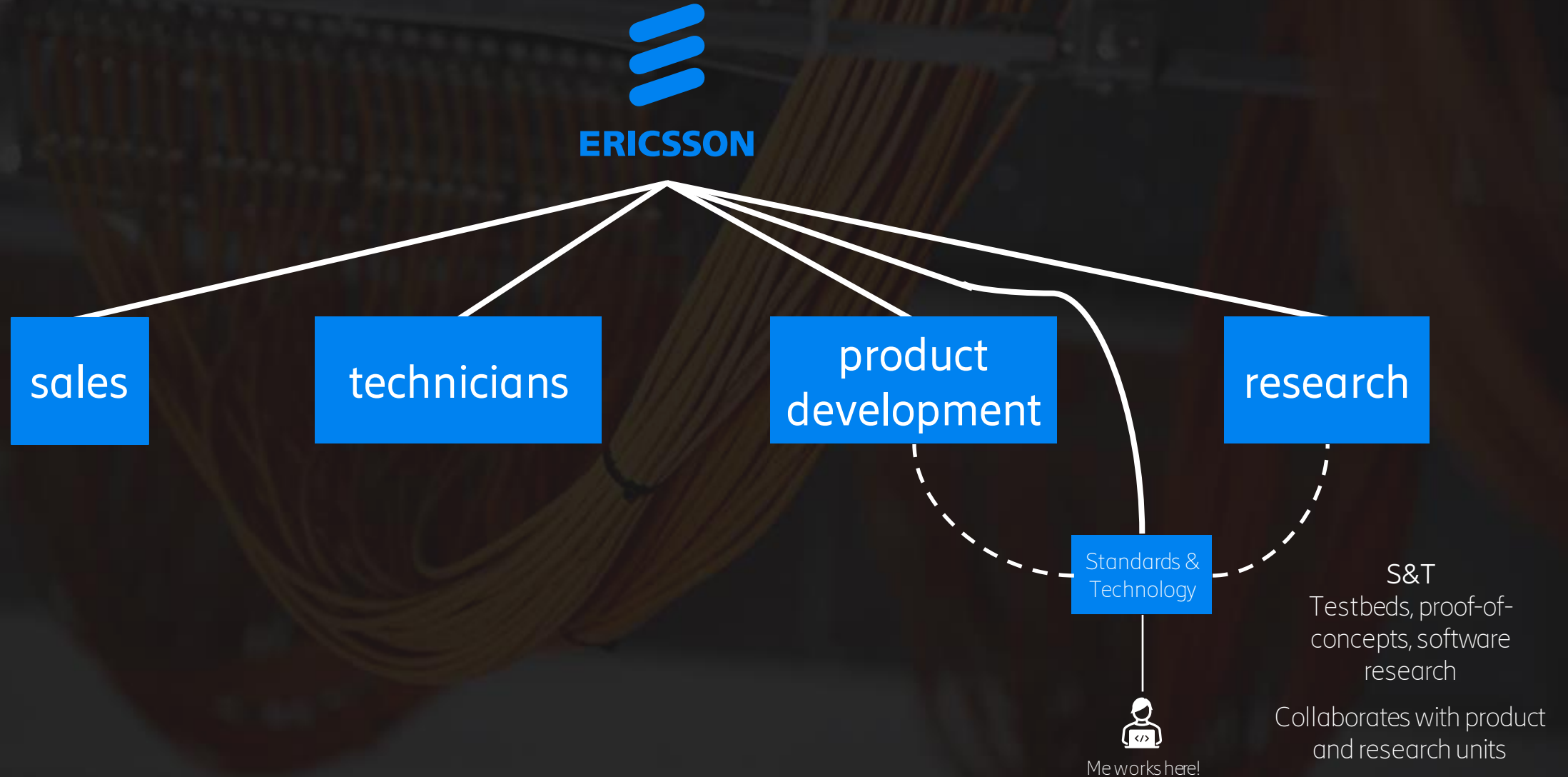
Probably Your View of Mobile Telephony ...



A More Detailed View



Organization



Optimization Problem #1: Site Hardware Dimensioning and Configuration

Hardware selection

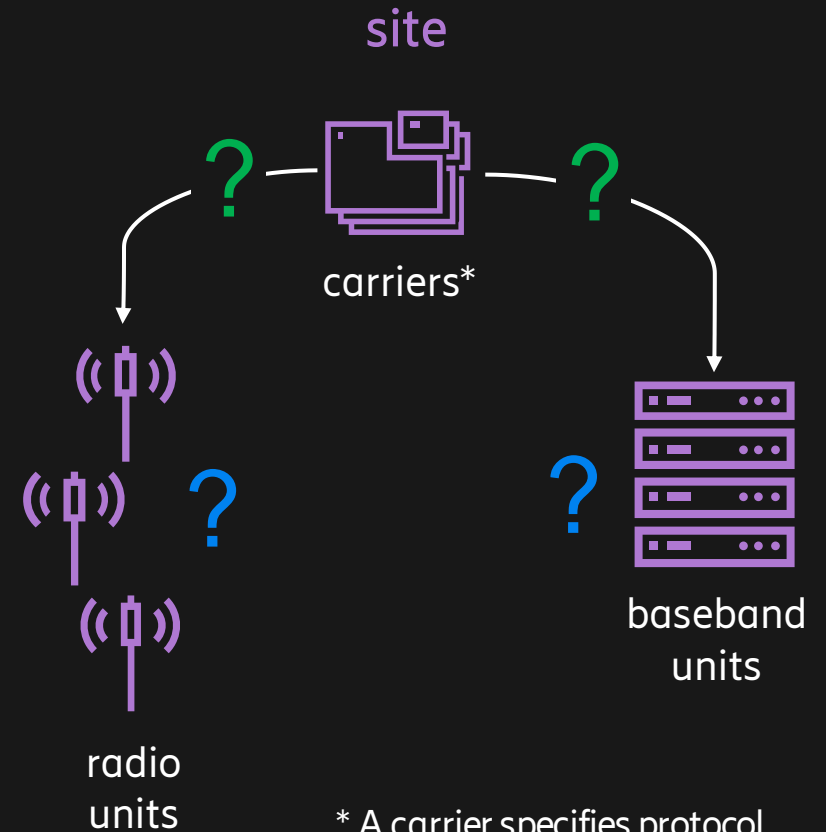
- Which radios/basebands to use?
 - 100x different radio units to choose between
 - 10x different baseband units to choose between
 - Many compatibility rules

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

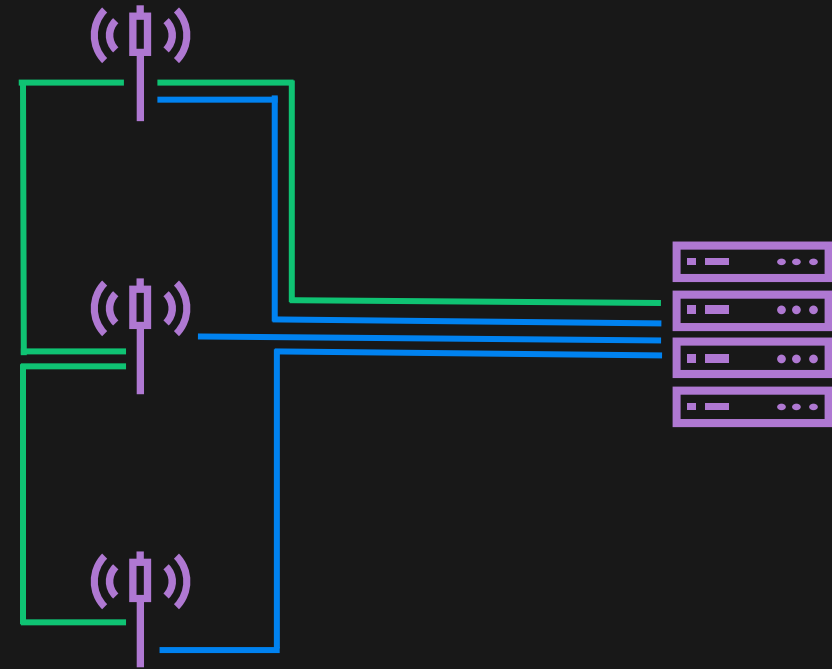
- How many links to use? Which ports to connect?
 - Many **link modes**
 - **Limited** number of ports
 - Direct connections may be **expensive**

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**



1. Carrier dimensioning

2. Solution configurator

3. Related products

Products

Search

Expand all

Collapse all

Drag and drop to add to solution.

RAN Compute

Baseband

Baseband 5212

Baseband 5216

Baseband 6303

Baseband 6318

Baseband 6502

Baseband 6620 w/ Fan

Baseband 6621



Canvas

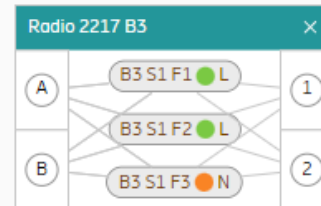
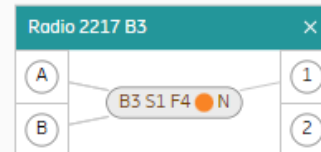
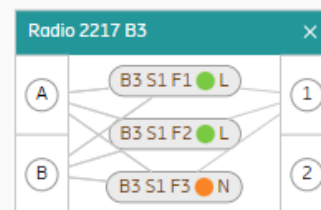
Expanded view

Horizontal View

4 / 4

Carrier in typesite configuration

Sector 1

Baseband 5216
(Throughput (THRP))

A

B

C

D

E

F

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

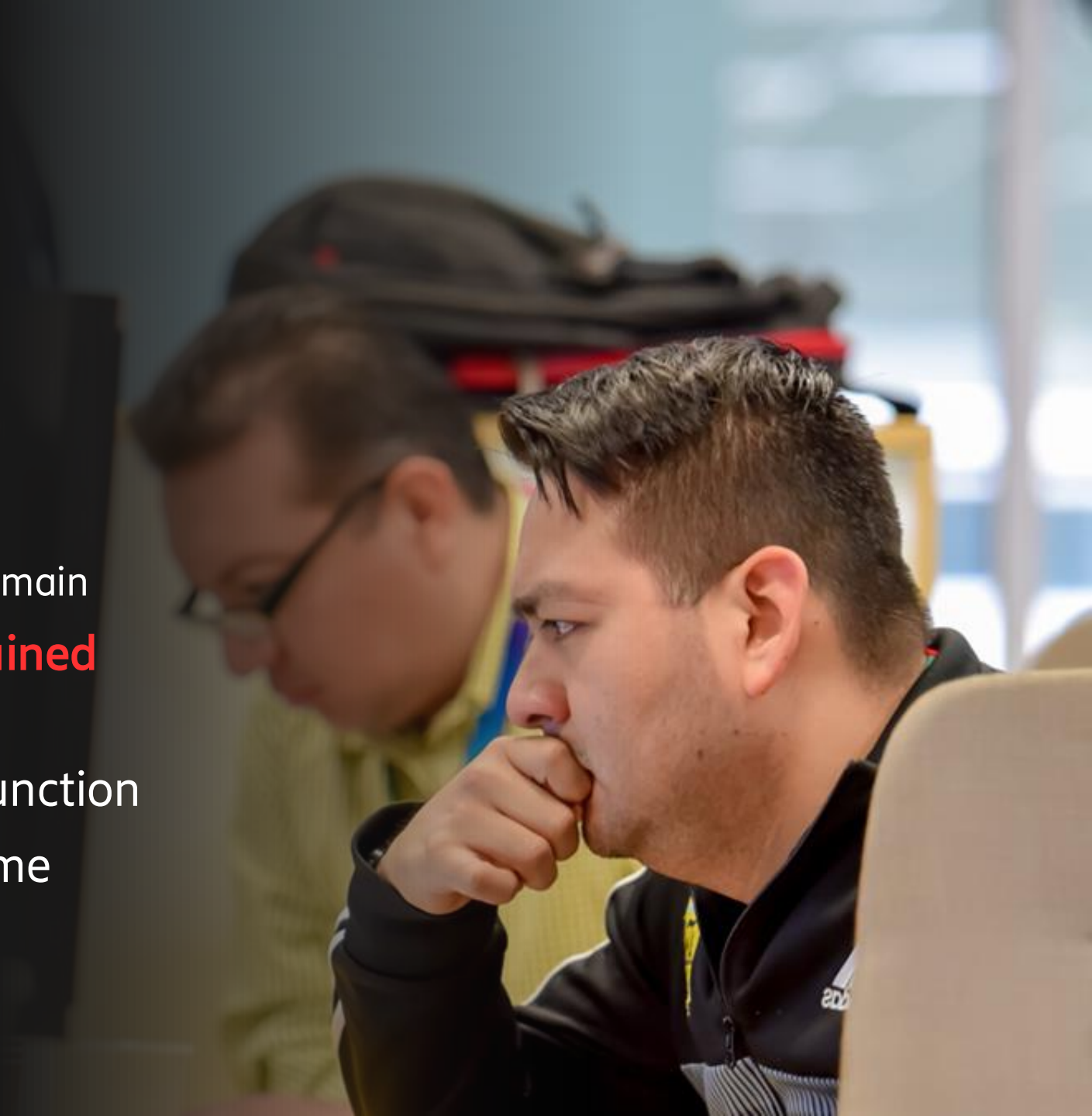
Testing, Verification, and Debugging

- **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**

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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**