

The Future of Software Development

How Open Source and AI are reshaping the way the world builds software



Tom Van Cutsem
Nokia Bell Labs



@tvcutsem

Bell Labs: the global innovation engine of Nokia

9 Nobel Prizes

4 Turing Awards

3 Emmys

2 Grammys

1 Oscar

Foundations of ...

- The entire electronics industry
- The internet, networking and optics
- Mobile and fixed communications



Transistors



Satellite comms



Laser/fiber optics



Unix/C/C++



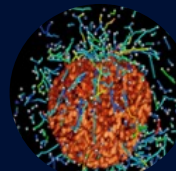
Solar cells



Coherent optics

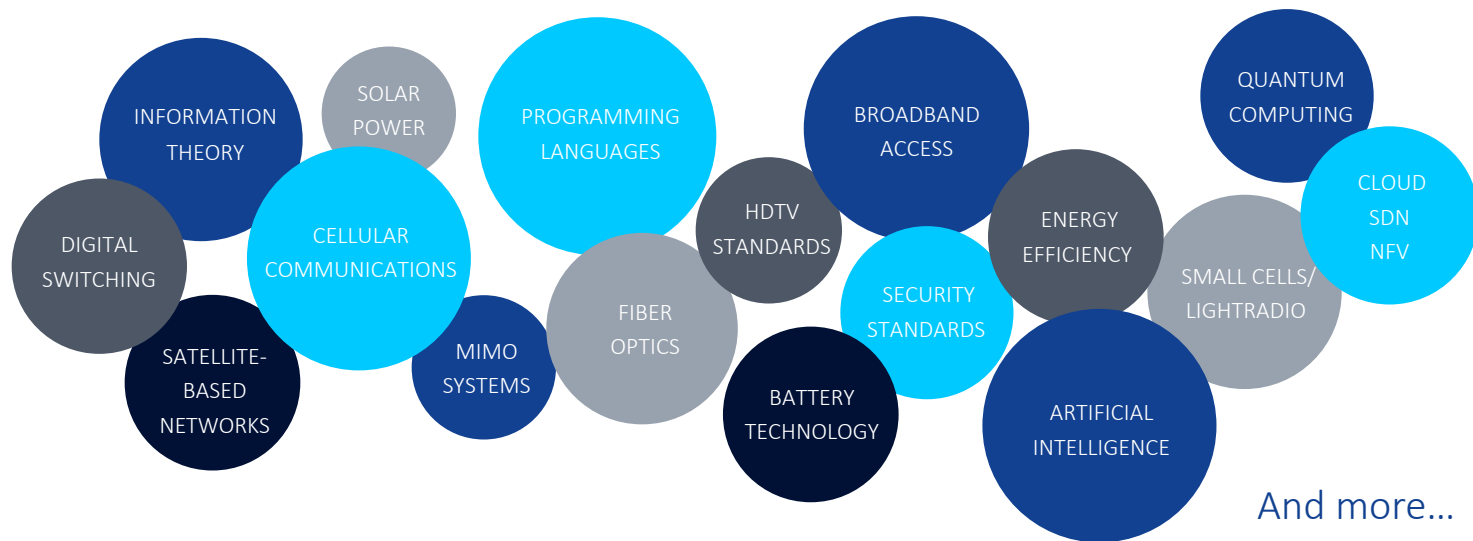


Charge-coupled
devices



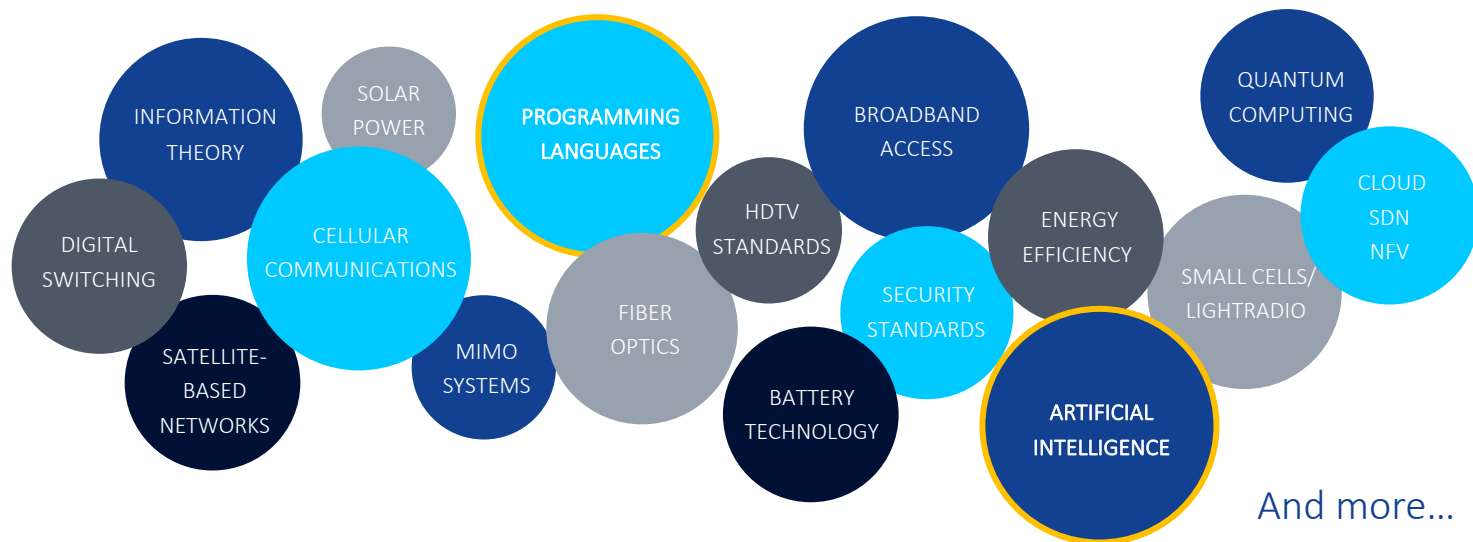
Super-resolution
microscopy

What is Bell Labs working on today?



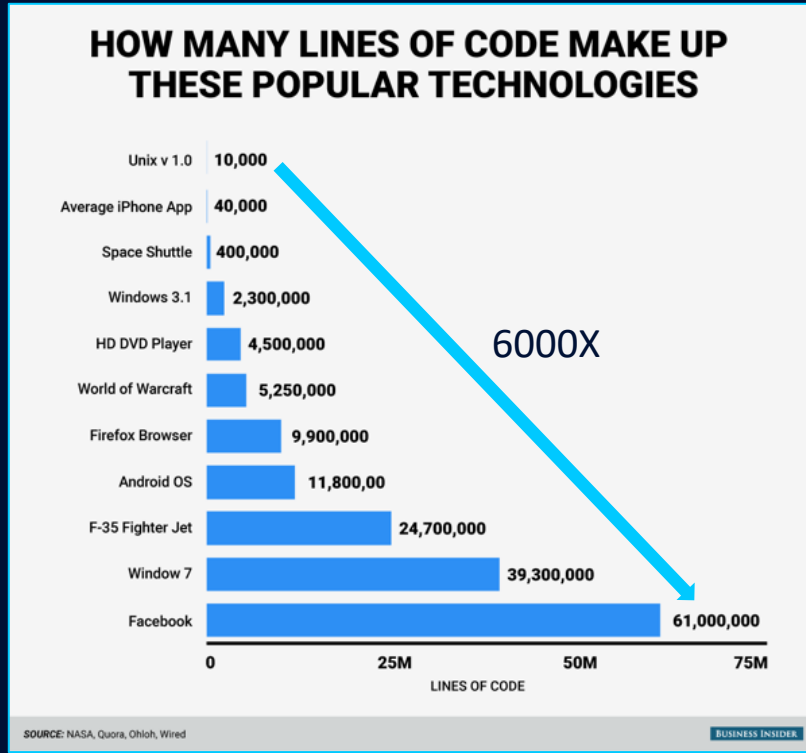
Solving the Big Challenges in Information and Communications Technology

What is Bell Labs working on today?



Solving the Big Challenges in Information and Communications Technology

Software is growing ever more complex...



“Google runs on 5000 times more code than the original space shuttle”

(World Economic Forum, 2016)

... and humans can't keep up

Growth in software complexity more than doubles the growth in software-development productivity.

Relative growth over time, for automotive features, indexed, 1 = 2010



Source: Numetrics

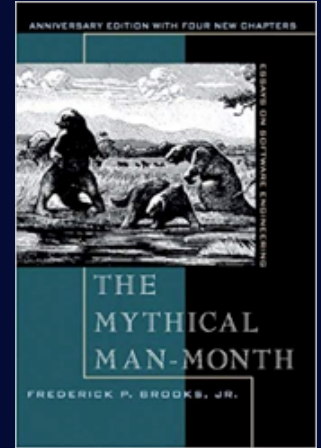
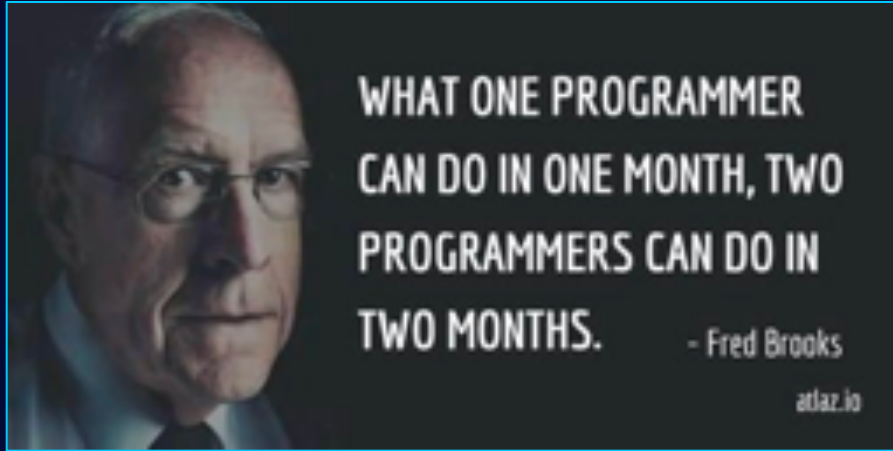
McKinsey
& Company



Kronosoft	edk
ansers	ibank
ansers-offers	inense
ansers-services	parde
hugh (andres)	plasma-partner-ito
hugh-andres	primafinance
codeborne-ix	rice-project
codeborne-web	waterer-reader-gps
corpses	waterer-web



Problem: software does not scale with human labor



Brooks's Law:

“adding manpower to a late software project makes it later”





pro'·gram·mer

An organism that
converts caffeine
into code



Developer Tools



Software Systems

UNIX

Make



Spin



Coq

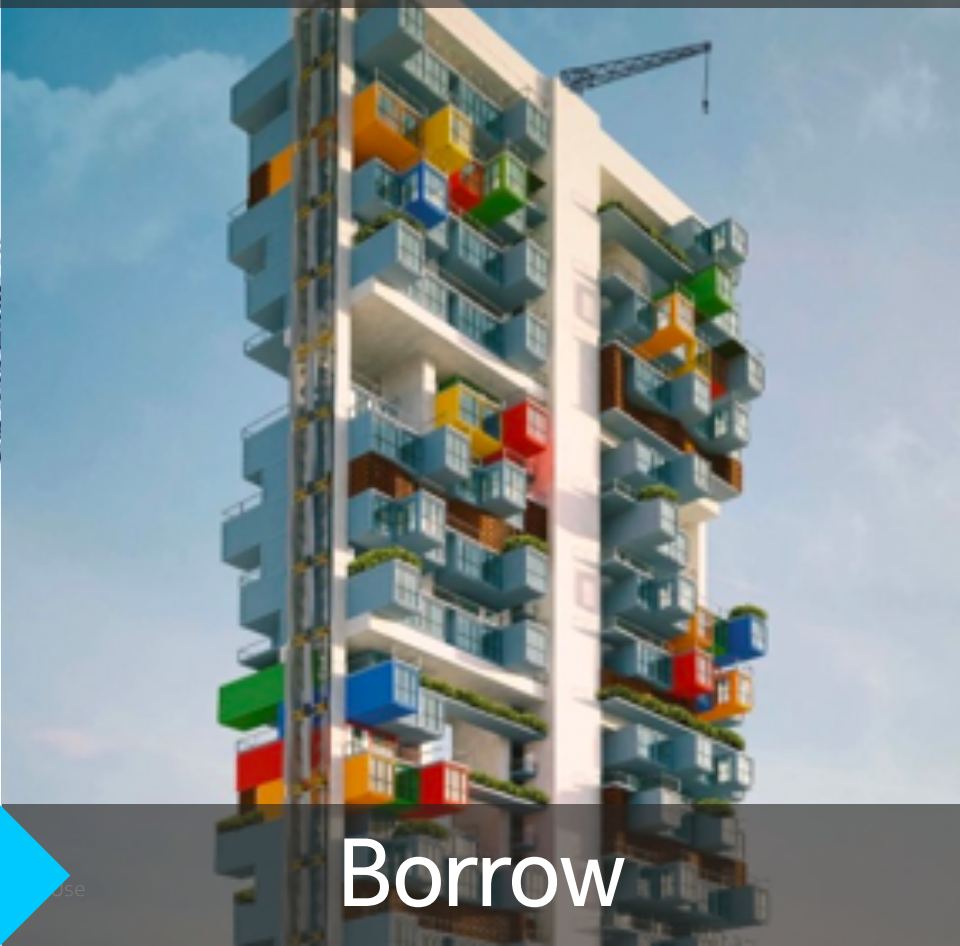


NOKIA Bell Labs

Game changer #1: Open Source







Build



Borrow

Modern software stacks: powerful, but complex

ML model building & training		 Keras	 PyTorch
		 TensorFlow	
Data analysis & visualization		 Seaborn	 Pandas
Vector math	 NumPy	 SciPy	
Parallel data processing	 PySpark	 DASK	
Language & Tools	 python™	 jupyter	 ANACONDA.



Example: the modern
Python machine learning
software stack

Developers waste significant time on finding and adapting existing code

ML model
building &
training



Data analysis &
visualization



Vector math



Parallel data
processing



Language
& Tools



up to 93%

of developers search for reusable code online
[Hucka et al., J. Systems and Software, 2018]

up to 35%

of developer worktime is spent on code search
[Xia et al., J. Empirical Software Engineering, 2017]

up to 66%

of community answers on StackOverflow are
outdated compared to their original source
[Raghitwetsagul et al., IEEE Trans. Softw. Eng., 2018]

Game changer #2: AI

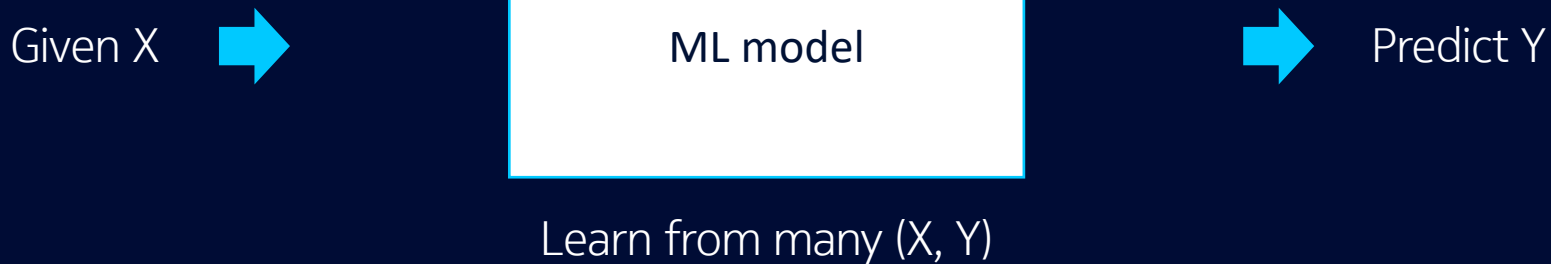


Program



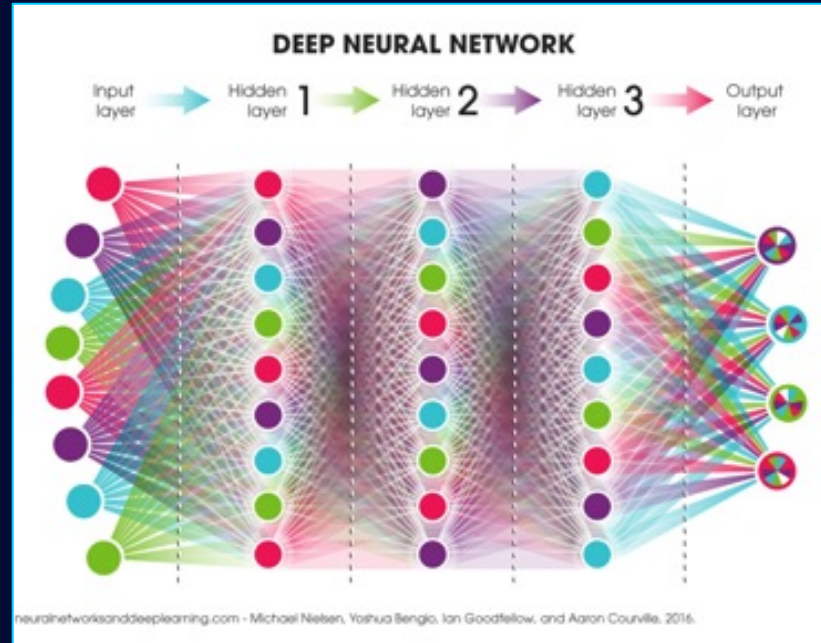
Learn

Machine learning is all about **prediction**



Machine learning is all about **prediction**

Given X



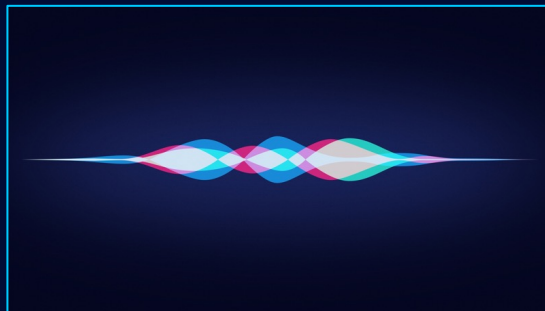
Predict Y

Learn from many (X, Y)

Deep neural networks enable computers to work with “natural” inputs



Vision



Speech

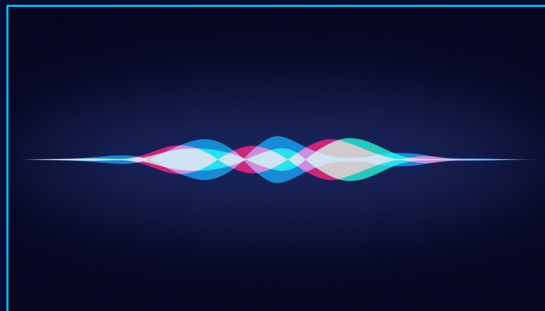


Text

Deep neural networks enable computers to work with “natural” inputs



Vision



Speech

```
60 int V[600];  
61 int V[600];  
62 int FD[600][600];  
63 int n2n[600];  
64 int Floyd(){  
65     for(int i=0; i<cnt; i++){  
66         for(int j=0; j<cnt; j++){  
67             if(i==j)  
68                 FD[i][j] = 0;  
69             else  
70                 FD[i][j] = 12001;  
71         }  
72     }  
73     for(int i = 0; i<cnt; i++){  
74         for(int j=0; j<G[i].size(); j++){  
75             G[i][j].cost;
```

Code?

Bell Labs is betting on AI Pair Programmers

- “Augment” human intelligence with artificial intelligence
- Developer tools that leverage Machine Learning to “understand” existing codebases and API documentation
- Enable developers to write better code, faster

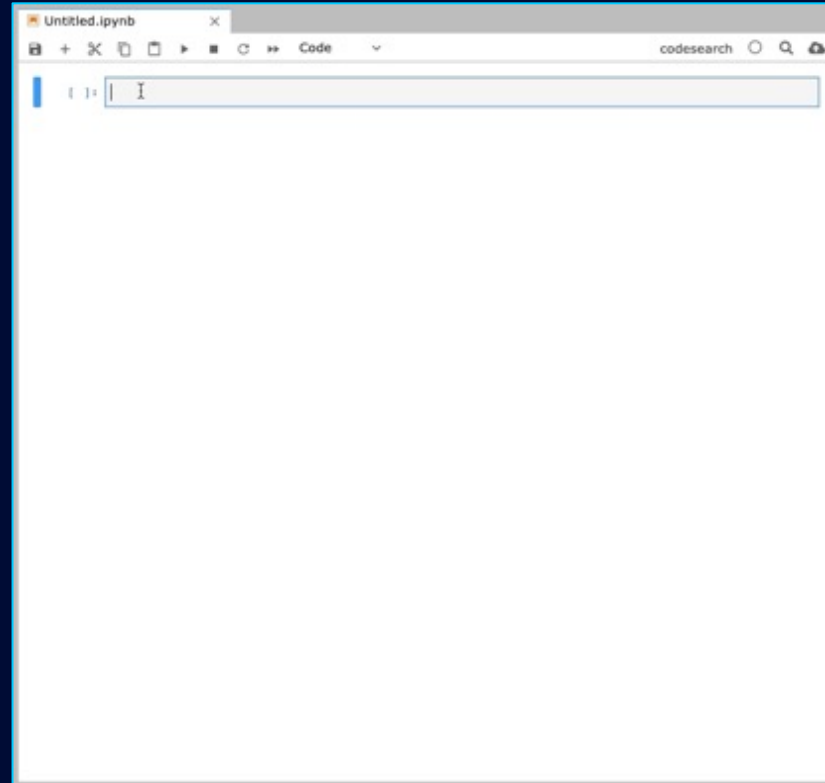


AI Pair Programming

AI Pair Programming



AI Pair Programming



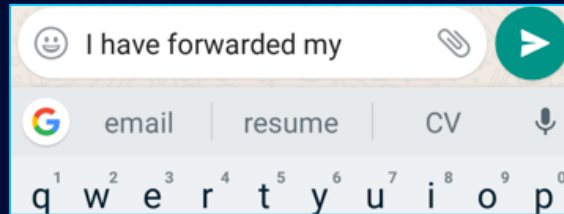
Machine Learning is all about **prediction**

I THOUGHT I WOULD ARRIVE ON TIME,
BUT ENDED UP 5 MINUTES ____.

(image credits: kdnuggets.com ; M. Rathore, mohitatgithub.github.io)

Machine Learning is all about **prediction**

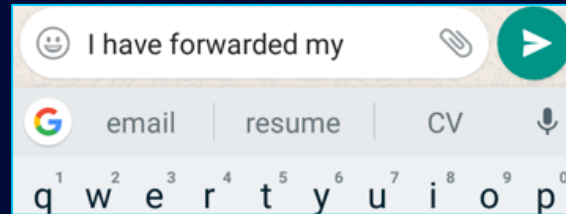
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Machine Learning is all about prediction

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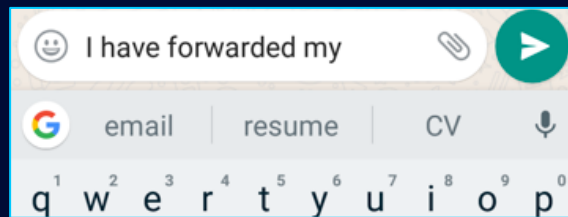


for (i = 0; i < n; _____)

(image credits: kdnuggets.com ; M. Rathore, mohitatgithub.github.io)

Machine Learning is all about **prediction**

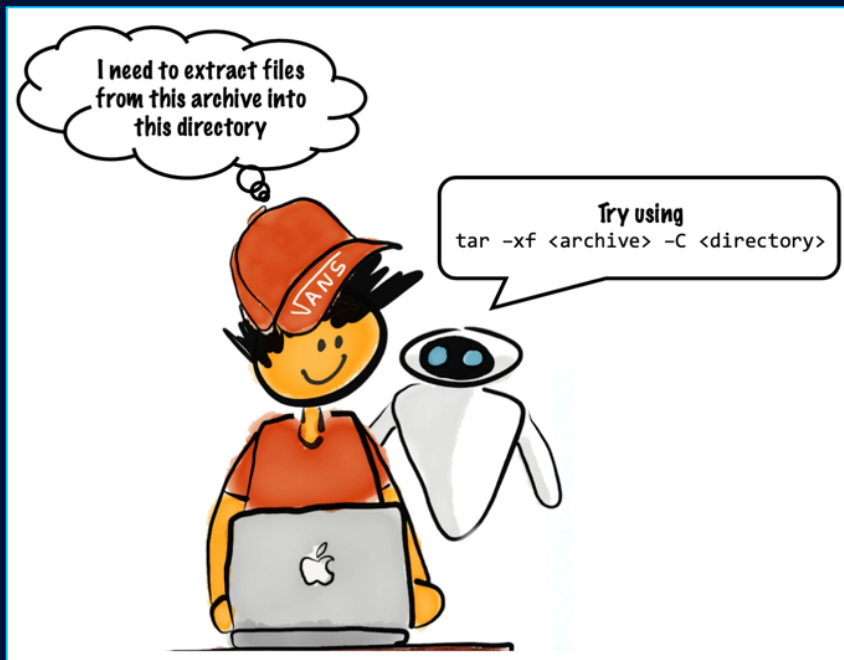
I THOUGHT I WOULD ARRIVE ON TIME,
BUT ENDED UP 5 MINUTES ____.



for (i = 0; i < n; i++)

(image credits: kdnuggets.com ; M. Rathore, mohitatgithub.github.io)

AI Pair Programming on the command line



AI assistant that can translate natural language commands into CLI commands

NLC2CMD Leaderboard

Team Name	Accuracy	Energy (mW)
Magnum	0.532 🟡	682.3
Hubris	0.513 🟡	809.6
jb	0.499	828.9
AICore	0.489	596.9 🟡
DeepBlueAI	0.482	670.7

- 2020 Summer internship by **KU Leuven** student
- Won **2nd Place** in NLC2CMD AI competition (organized by IBM)
- Invited to present at **NeurIPS** workshop
- github.com/nokia/nlc2cmd-submission-hubris

Bell Labs AI Pair Programmer tools

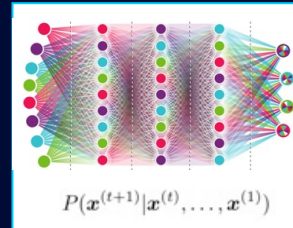
Source **code** and
API documentation

```
int V[600];
int FD[600][600];
int nzn[600];

int floyd(){
    for(int i=0; i<cnt; i++){
        for(int j=0; j<cnt; j++){
            if(i==j)
                FD[i][j] = 0;
            else
                FD[i][j] = 12001;
        }
    }
    for(int i = 0; i<cnt; i++){
        for(int j=0; j<ad[i].size(); j++){
            for(int k=0; k<ad[i].size(); k++){
                if(ad[i][j].cost < ad[i][k].cost + FD[i][k].cost)
                    FD[i][j] = ad[i][k].cost + FD[i][k].cost;
            }
        }
    }
}
```



Train AI **models**



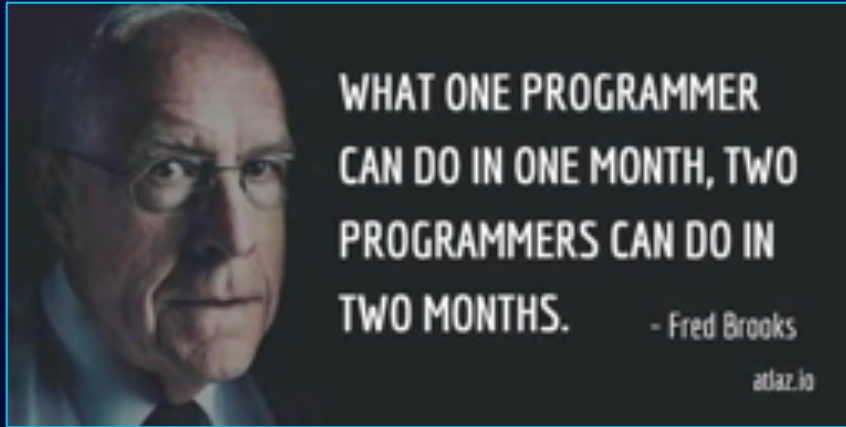
Actionable **tools**
for Nokia R&D



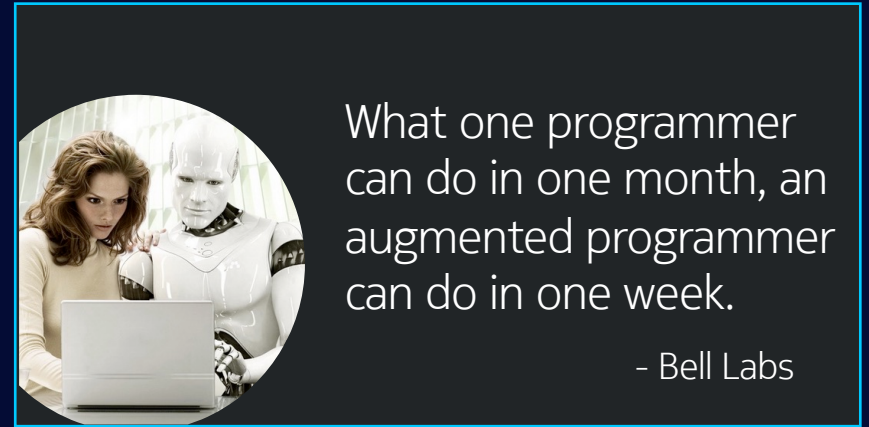
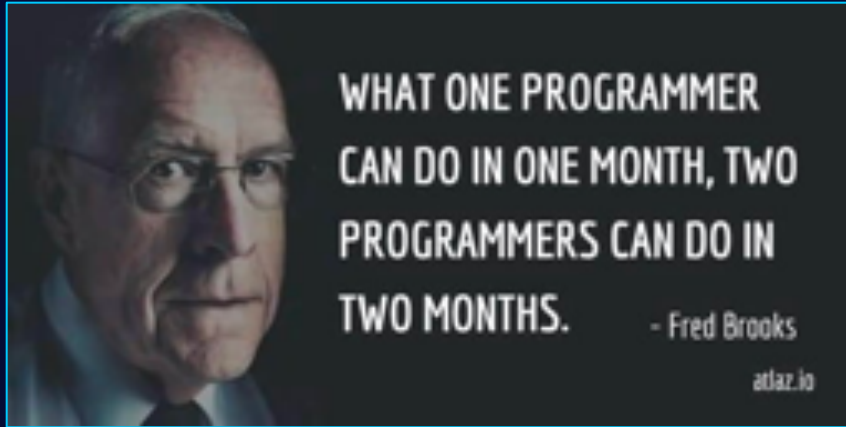
Summary

- Software is growing ever more complex... and humans can't keep up
- Machine Learning enables us to reimagine developer tools
- Bell Labs is building AI Pair Programmers to augment human programmers

The take-away

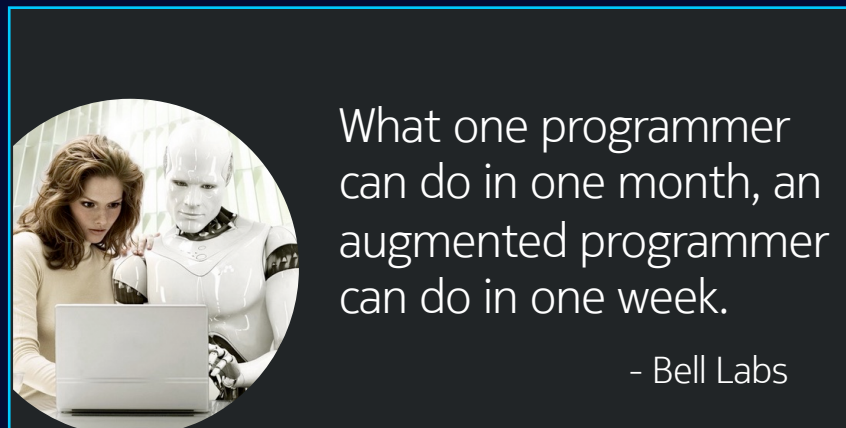
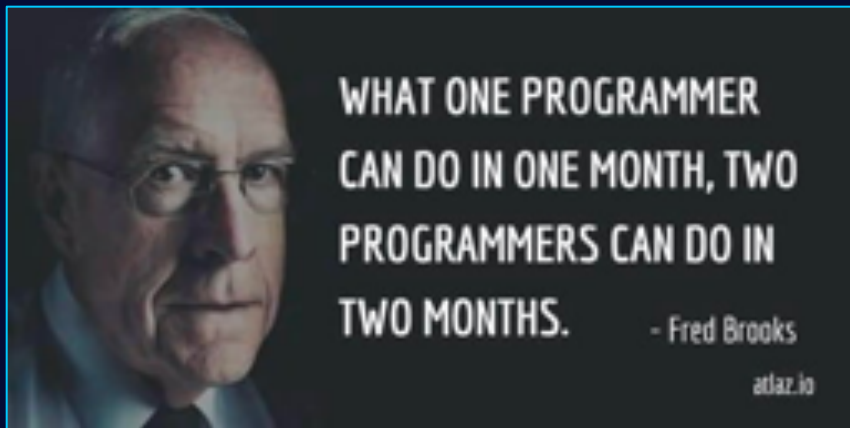


The take-away



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 @tvcutsem

Thanks for listening!

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