

# 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++



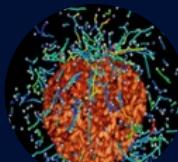
Solar cells



Coherent optics

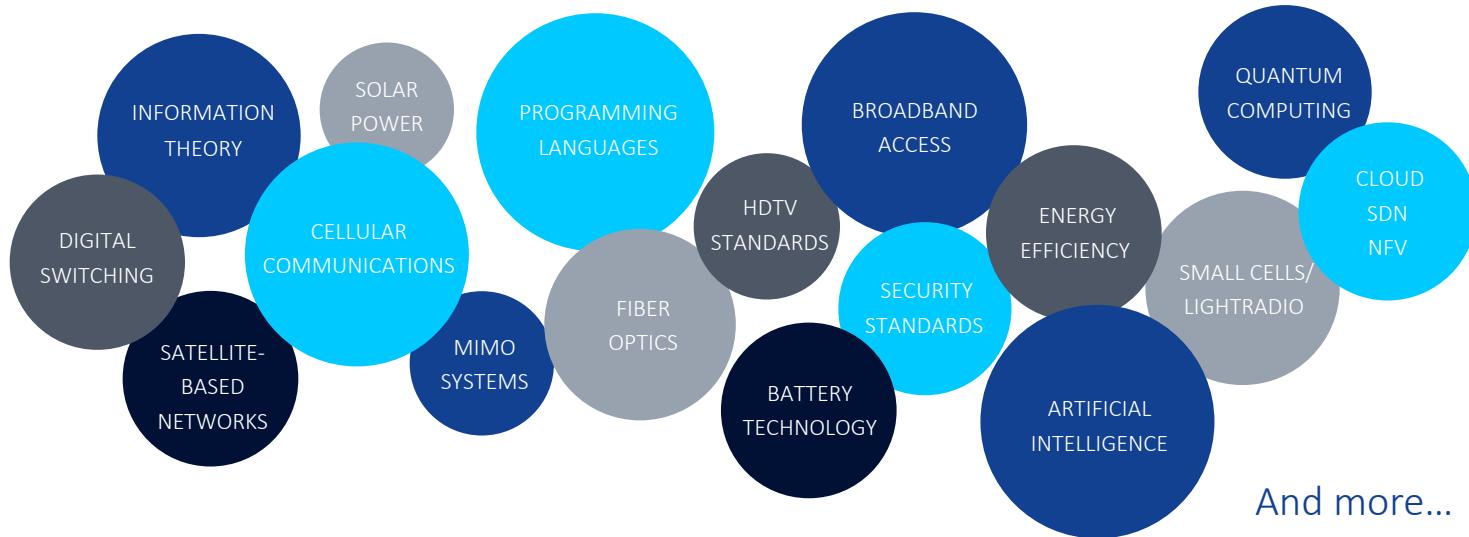


Charge-coupled devices



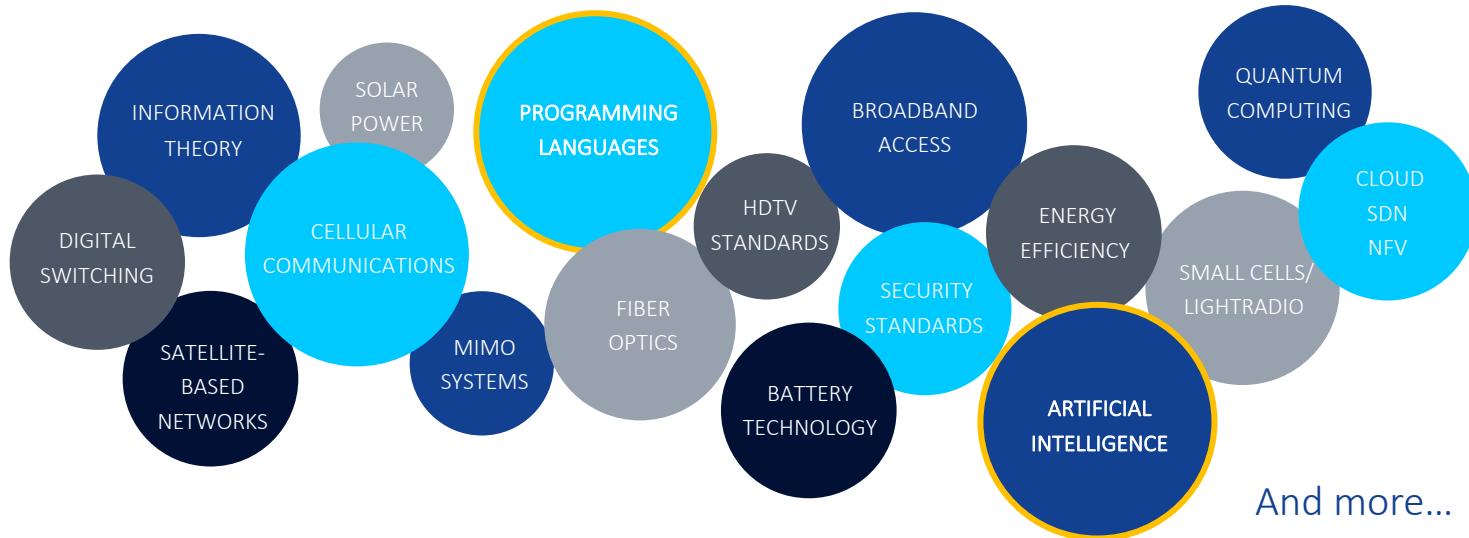
Super-resolution microscopy

# What is Bell Labs working on today?



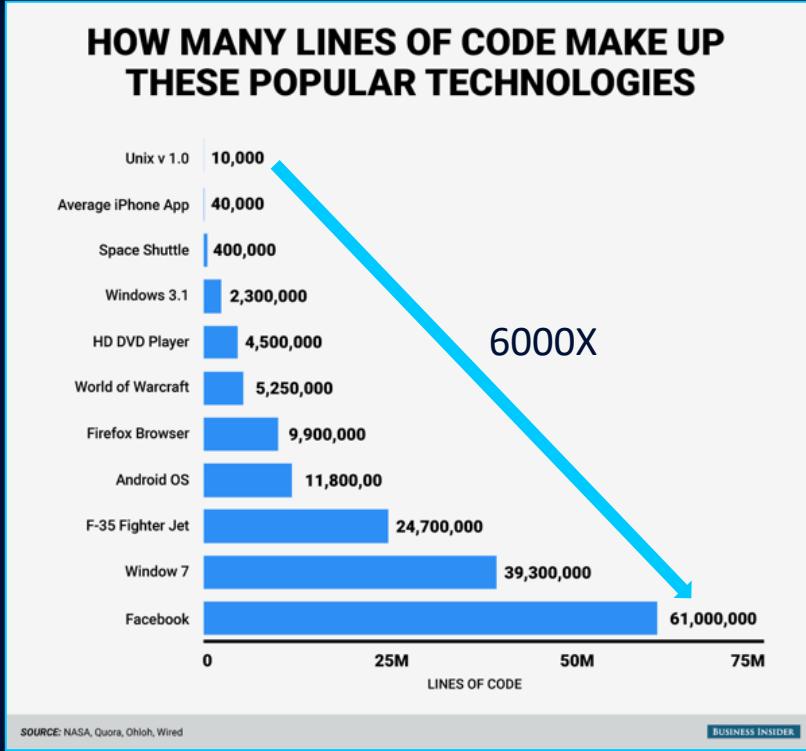
Solving the Big Challenges in Information and Communications Technology

# 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



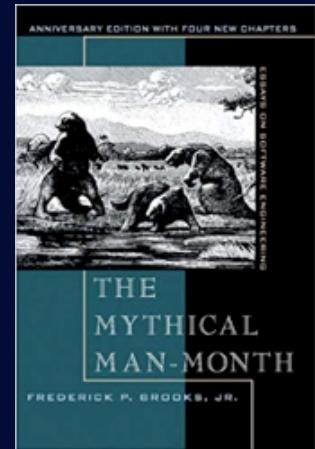
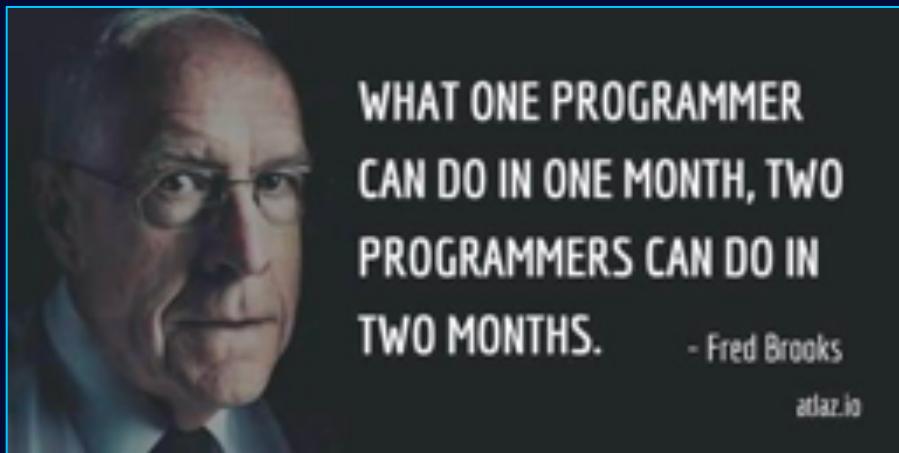
Source: Numerics

McKinsey  
& Company





# 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



GCC

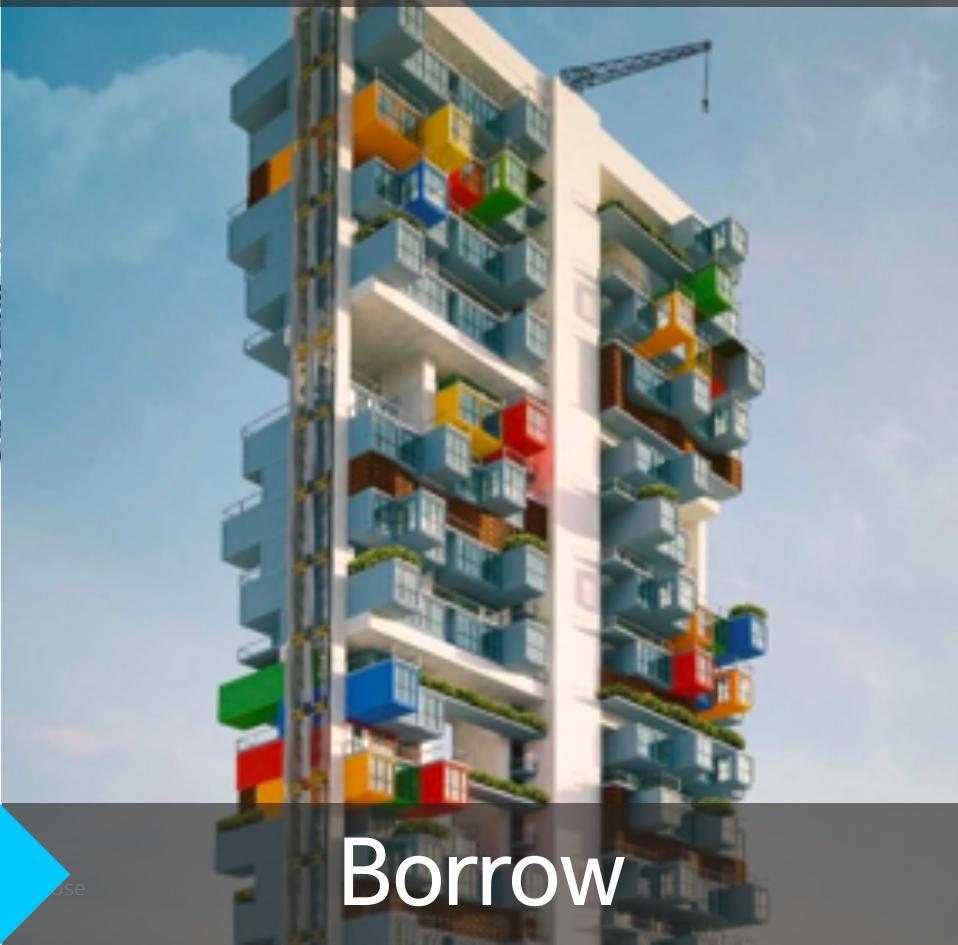


NOKIA Bell Labs

# Game changer #1: Open Source

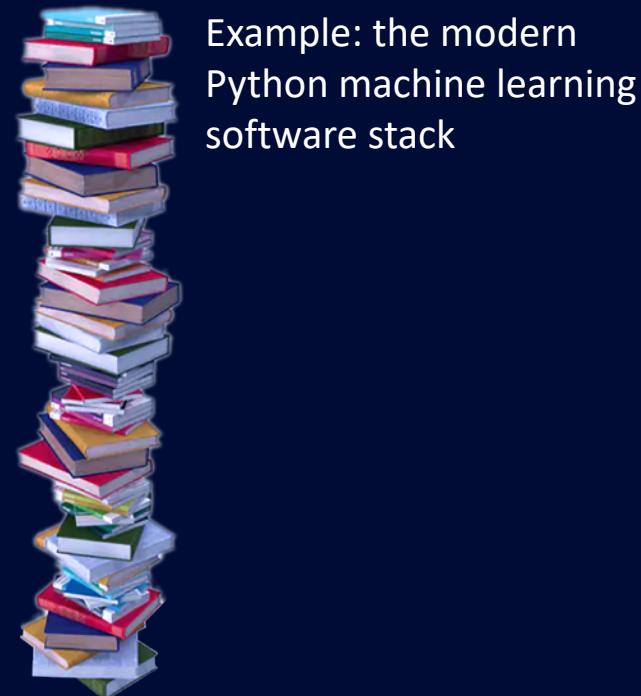


Build



Borrow

# Modern software stacks: powerful, but complex



Example: the modern Python machine learning software stack

# Developers waste significant time on finding and adapting existing code

ML model  
building &  
training



K Keras



O PyTorch



Data analysis &  
visualization

matplotlib



Seaborn



Vector math



NumPy



Parallel data  
processing

PySpark



Language  
& Tools

python™



anaconda

up to 93%

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

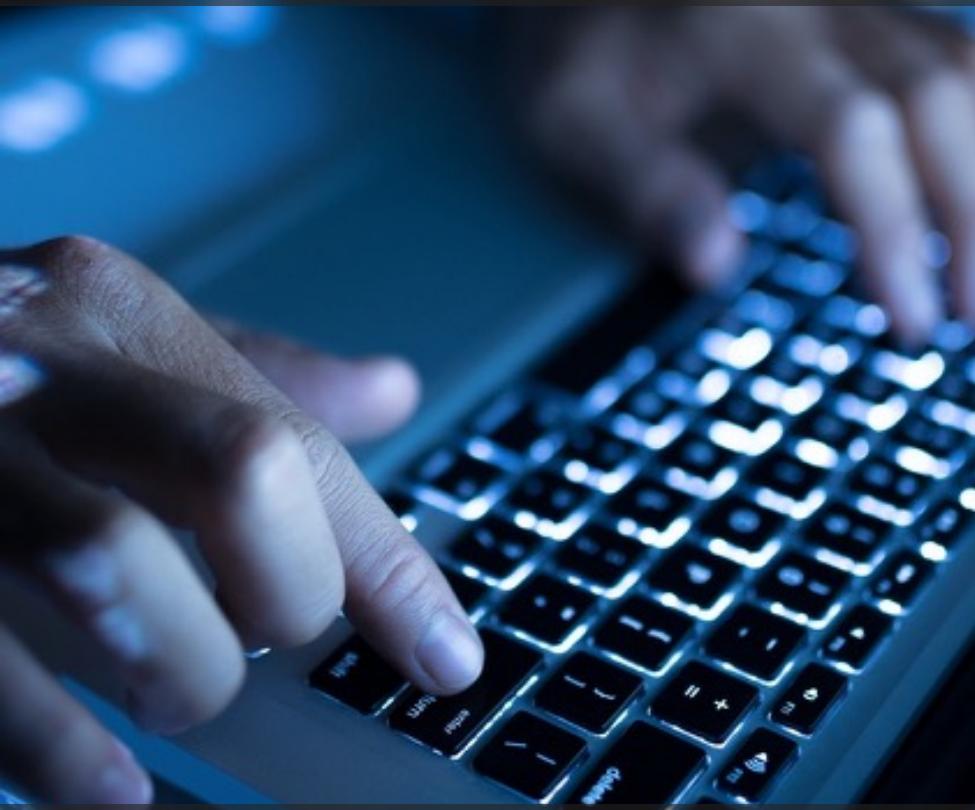
up to 35%

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

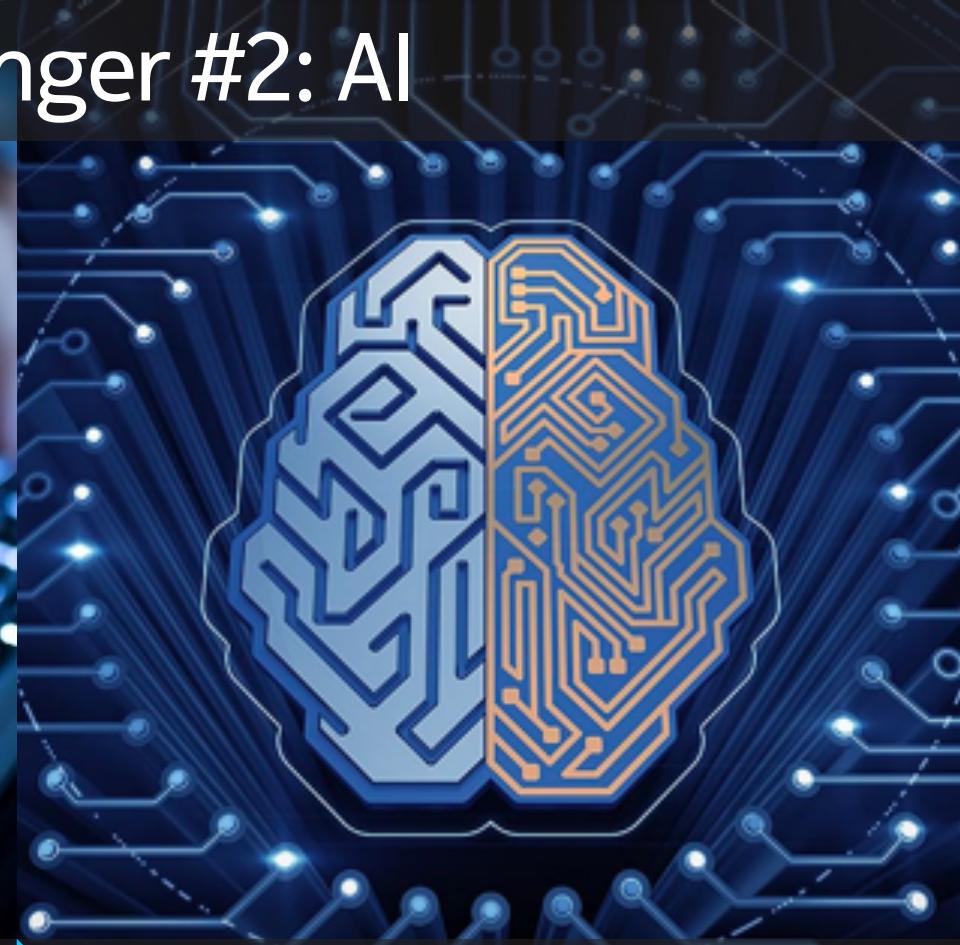
up to 66%

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

# Game changer #2: AI



Program



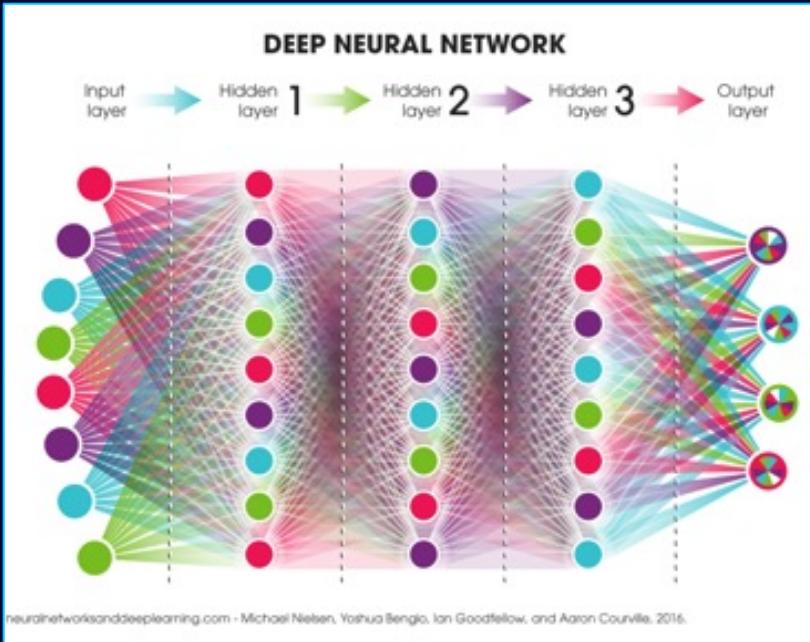
Learn

# Machine learning is all about **prediction**



# Machine learning is all about prediction

Given X



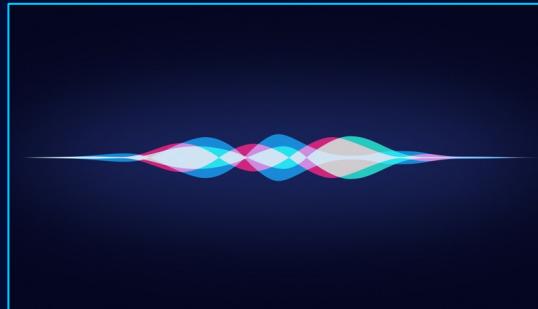
Predict Y

Learn from many (X, Y)

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



Vision



Speech

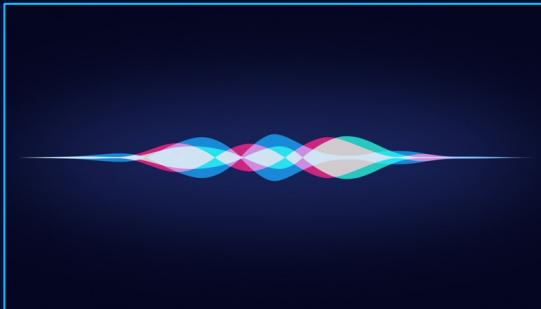
Back in 2000, People Magazine [highlighted Prince William's style](#). At the time was a little more fashion-conscious, even making fashion statements at the 2002 Commonwealth Games. Now-a-days the prince mainly wears navy [double-breasted suits](#) (sometimes light blue [button-ups](#) with pointed [collars](#)), and burgundy [ties](#). But who knows what the future holds ... Duchess Kate [did wear an Alexander McQueen wedding dress](#) in the fall of 2017 [SESSION](#).

Text

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



Vision



Speech

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

Code?

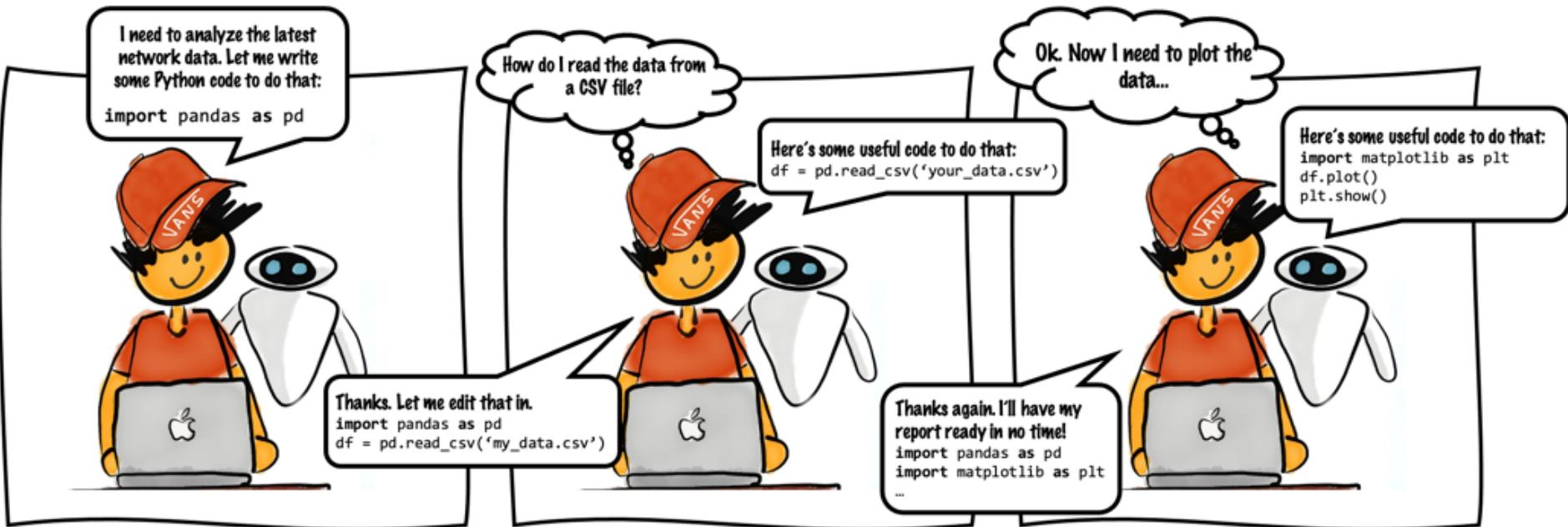
# Bell Labs is betting on AI Pair Programmers

- “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

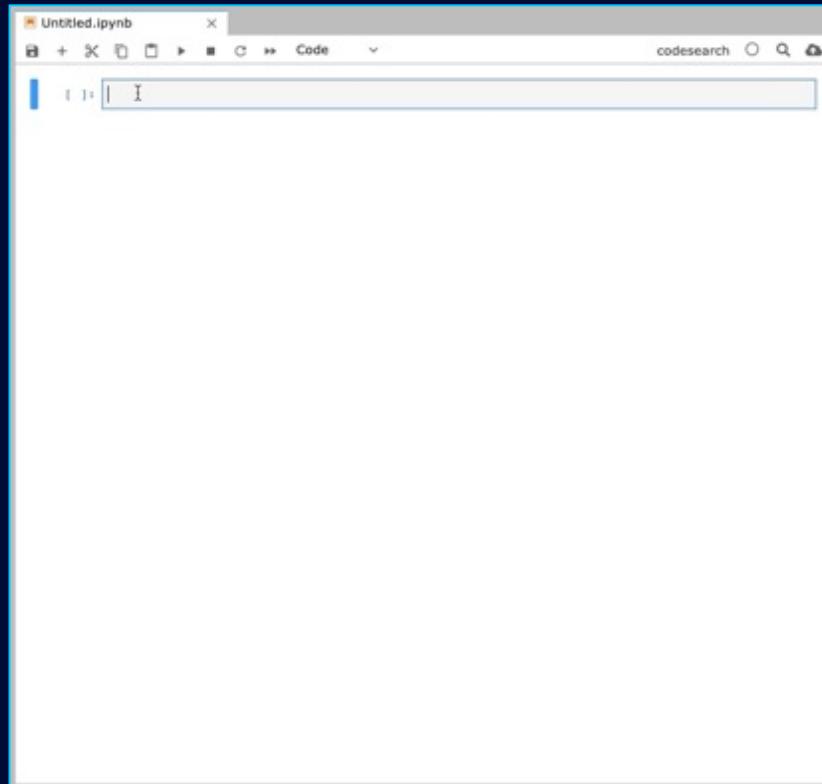


AI Pair Programming

# AI Pair Programming



# AI Pair Programming



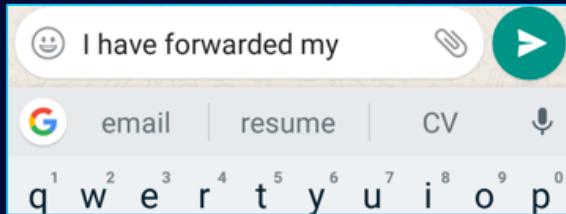
# Machine Learning is all about prediction

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

(image credits: [kdnuggets.com](https://kdnuggets.com) ; M. Rathore, mohitatgithub.github.io )

# Machine Learning is all about prediction

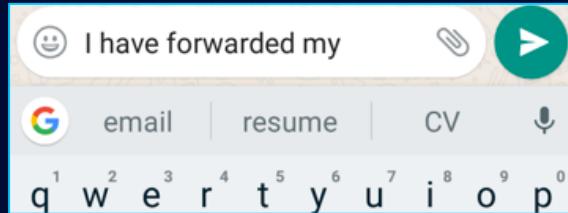
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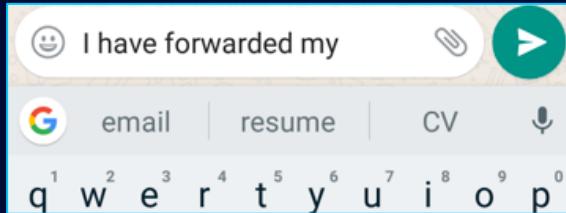


```
for (i = 0; i < n; _____)
```

(image credits: [kdnuggets.com](http://kdnuggets.com) ; M. Rathore, [mohitatgithub.github.io](https://mohitatgithub.github.io) )

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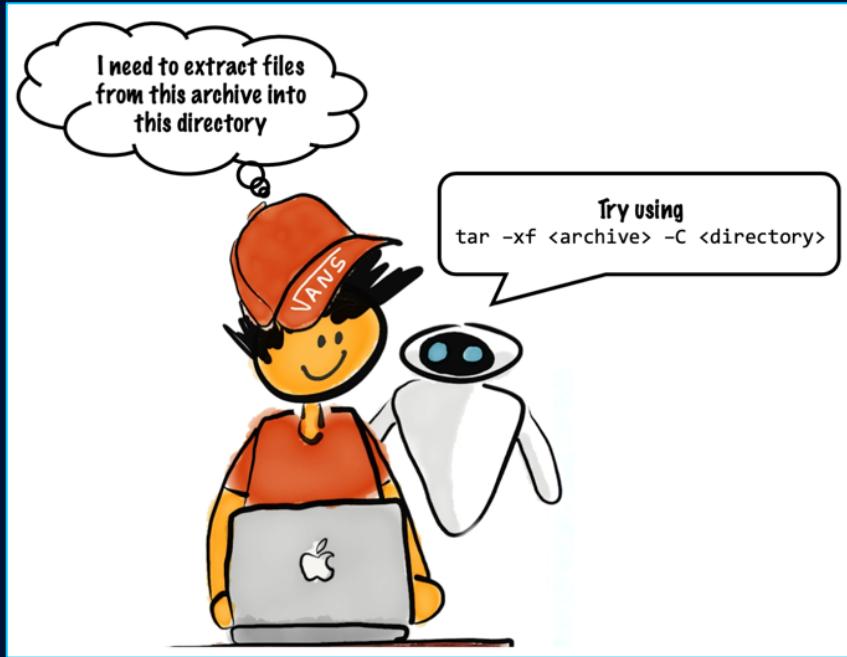
I THOUGHT I WOULD ARRIVE ON TIME,  
BUT ENDED UP 5 MINUTES \_\_\_\_.



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

(image credits: [kdnuggets.com](http://kdnuggets.com) ; M. Rathore, [mohitatgithub.github.io](https://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 **2<sup>nd</sup> Place** in NLC2CMD AI competition (organized by IBM)
- Invited to present at **NeurIPS** workshop
- [github.com/nokia/nlc2cmd-submission-hubris](https://github.com/nokia/nlc2cmd-submission-hubris)

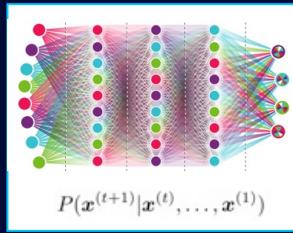
# Bell Labs AI Pair Programmer tools

Source **code** and  
API documentation

```
Line 1: int V[600];  
Line 2: int FD[600][600];  
Line 3: int n2n[600];  
Line 4: int floyd(){  
Line 5:     for(int i=0; i<cnt; i++){  
Line 6:         for(int j=0; j<cnt; j++){  
Line 7:             if(i==j)  
Line 8:                 FD[i][j] = 0;  
Line 9:             else  
Line 10:                 FD[i][j] = 12000;  
Line 11:         }  
Line 12:         for(int i = 0; i<cnt; i++){  
Line 13:             for(int j=0; j<n2n[i].size(); j++){  
Line 14:                 int t = n2n[i].to = G[i][j].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



WHAT ONE PROGRAMMER  
CAN DO IN ONE MONTH, TWO  
PROGRAMMERS CAN DO IN  
TWO MONTHS.

- Fred Brooks

atlas.io

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Thanks for listening!

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