



# STUDENT IEEE AAU BRANCH

Writing beautiful documents

*with*

**LATEX**

Alessandro Crismani

6<sup>th</sup> June 2013

**ONE DOES NOT  
SIMPLY**



**WRITE A RESEARCH PAPER**

## SO YOU THINK WORD AND MATLAB SHOULD SUFFICE...

$$Th = \frac{(1 - e^{-\alpha G})^M \cdot Ps \cdot e^{-\alpha G(M-1)}}{1 + \alpha - e^{-\alpha G}}$$

## SO YOU THINK WORD AND MATLAB SHOULD SUFFICE...

$$Th = \frac{(1 - e^{-\alpha G})^M \cdot Ps \cdot e^{-\alpha G(M-1)}}{1 + \alpha - e^{-\alpha G}}$$

$$P_K = \sum_{i=k}^N \binom{N}{i} p^i Q^{N-i}$$

## SO YOU THINK WORD AND MATLAB SHOULD SUFFICE...

$$Th = \frac{(1 - e^{-\alpha G})^M \cdot Ps \cdot e^{-\alpha G(M-1)}}{1 + \alpha - e^{-\alpha G}}$$

$$\begin{aligned} F_{BR} &= \Pr(x < \gamma_{th} N_0) = 1 - \Pr(x > \gamma_{th} N_0) \\ &= 1 - \int_{\gamma_{th} N_0}^{\infty} \frac{1}{P_{rk}} \exp\left(-\frac{x}{P_{rk}}\right) dx = 1 - \exp\left(-\frac{\gamma_{th}}{P_{rk}}\right) \end{aligned} \quad (8)$$

fail

$$P_K = \sum_{i=k}^N \binom{N}{i} p_i^i q_o^{N-i}$$

??

# SO YOU THINK WORD AND MATLAB SHOULD SUFFICE...

$$Th = \frac{(1 - e^{-\alpha G})^M \cdot Ps \cdot e^{-\alpha G(M-1)}}{1 + \alpha - e^{-\alpha G}}$$

$$\begin{aligned} F_{BR} &= \Pr(x < \gamma_{th} N_0) = 1 - \Pr(x > \gamma_{th} N_0) \\ &= 1 - \int_{\gamma_{th} N_0}^{\infty} \frac{1}{P_{RK}} \exp\left(-\frac{x}{P_{RK}}\right) dx = 1 - \exp\left(-\frac{\gamma_{th}}{P_{RK}}\right) \end{aligned} \quad (8)$$

$$P_K = \sum_{i=k}^N \binom{N}{i} p^i Q_a^{N-i}$$

Plug (9) (10) (17) into (16), and the capacity is obtained as follows: the primary user's capacity is:

$$C_p = 1 - H(\frac{1}{2} \operatorname{erfc}(\sqrt{\frac{P_p^2 h_{a,b}^2 / N + \alpha |h_{a,c}|^2 |h_{c,b}|^2 P_s P_a}{(\alpha |h_{a,b}|^2 P_s + 1)N}})) \quad (18)$$

and the secondary user capacity is:

 size, wtf?

User A selects a cooperator, this factor should be considered first.



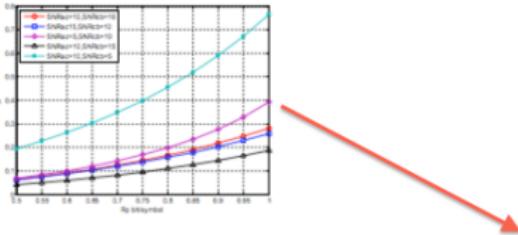
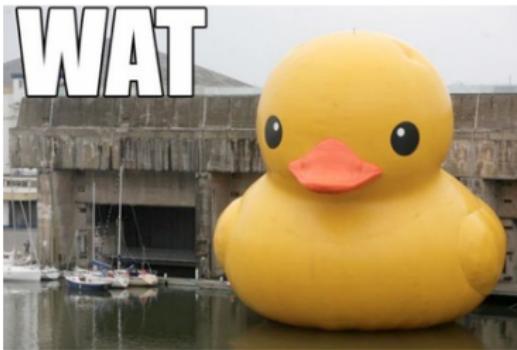
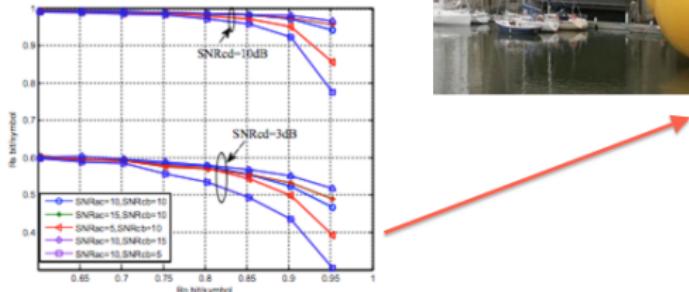


Figure 4.  $\alpha$  with different requirement of primary user

Fig. 4 shows the  $\alpha$  numerical evolution with different requirement of primary user. As shown in Figure 4,  $\alpha$  is a rising trend with the escalation of the requirement. We also find that the channel quality of link BC affects  $\alpha$  more greatly than link AC. When the channel quality of link AC changes a lot,  $\alpha$  just changes a little. Different from the former case, link CB can make  $\alpha$  change more. Hence, when User A selects a cooperator, this factor should be considered first.



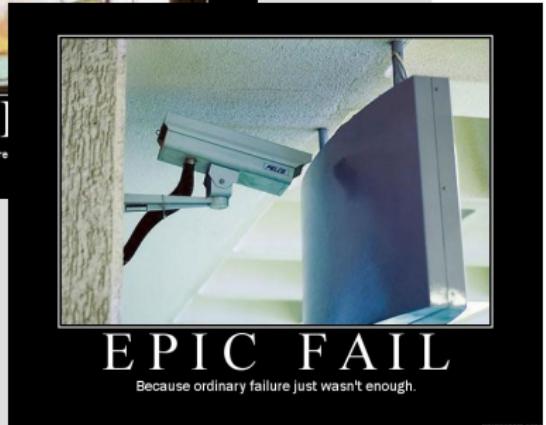
...THEY DON'T!



EPIC FAIL

For some things, there's just no excuse

...THEY DON'T!



©2001 DDB Worldwide

...THEY DON'T!



EPIC

A composite image featuring a game show host and a graphic. The host, a woman with short blonde hair, is speaking on a dark blue background. To her right, the word "FAIL" is displayed in large white letters. Below "FAIL", a smaller line of text reads "just wasn't enough." In the bottom right corner of the image area, there is a small graphic of a blue cabinet or shelving unit.

Which of the following is the largest?

+A: An Elephant

+C: The Moon

FAIL  
just wasn't enough.

©2008 Nickelodeon

...THEY DON'T!



**FACEPALM**

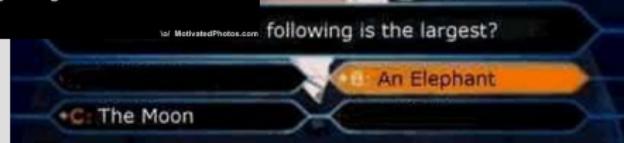
You're doing it wrong



**FAIL.**

**FAIL**

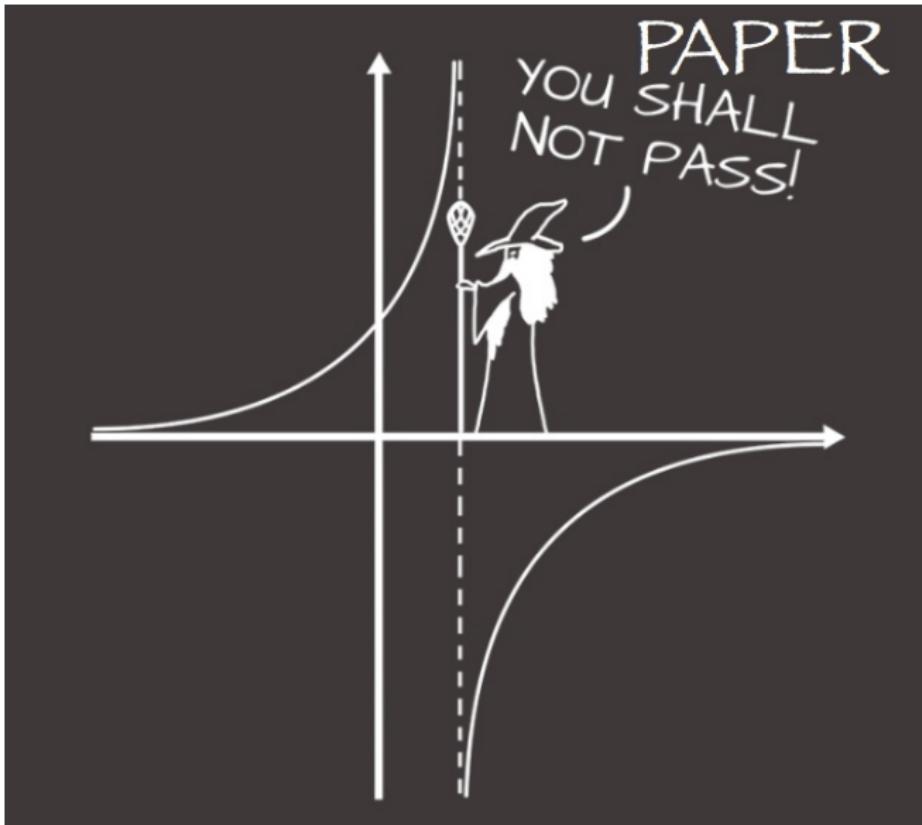
ust wasn't enough.



AND THEN THE REVIEWER SAYS ...

---

AND THEN THE REVIEWER SAYS ...



CAN WE MAKE IT LOOK BETTER?

YES

- ▶  $\text{\LaTeX}$
- ▶  $\text{TikZ}$
- ▶  $\text{PGF}$
- ▶  $\text{Gnuplot} \rightarrow \text{TikZ}$
- ▶  $\text{matplotlib} \rightarrow \text{TikZ}$

IS IT EASIER THAN WORD OR MATLAB OR "YOU NAME IT"?

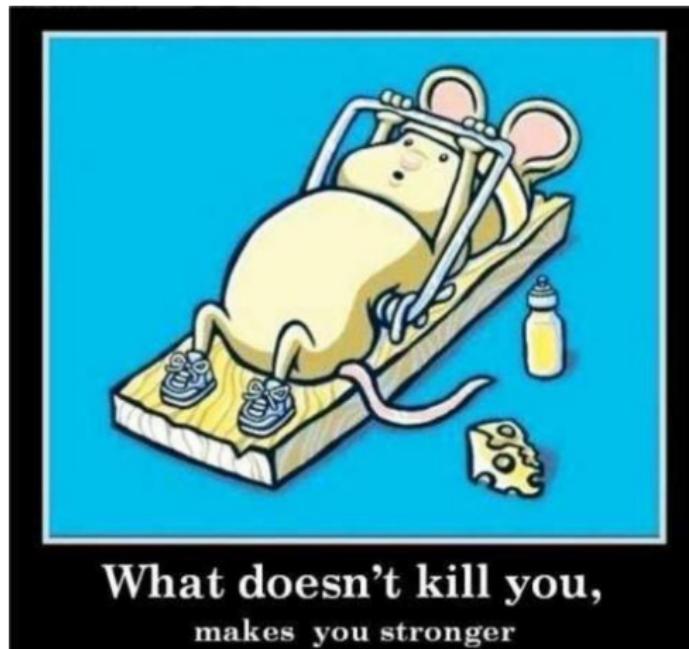
Probably NOT

No easy cake, however:

IS IT EASIER THAN WORD OR MATLAB OR "YOU NAME IT"?

# Probably NOT

No easy cake, however:



# A SIMPLE L<sup>A</sup>T<sub>E</sub>X DOCUMENT

```
\documentclass[a4]{article}

% Included packages, graphix for pictures
% and babel for hyphenation and spelling
\usepackage{graphicx}
\usepackage[english]{babel}

\begin{document}

This is a simple \LaTeX document

\end{document}
```

## MATH USING L<sup>A</sup>T<sub>E</sub>X

Math looks awesome, and it is easy too!

```
inline math $a^2 + b^3$
```

inline math  $a^2 + b^3$

## MATH USING L<sup>A</sup>T<sub>E</sub>X

Math looks awesome, and it is easy too!

```
inline math $a^2 + b^3$
```

inline math  $a^2 + b^3$

```
subscript $\gamma_{SR} \sim \mathcal{N}(0, 1)$
```

subscript  $\gamma_{SR} \sim \mathcal{N}(0, 1)$

# MATH USING LATEX

Math looks awesome, and it is easy too!

```
inline math $a^2 + b^3$
```

inline math  $a^2 + b^3$

```
subscript $\gamma_{SR} \sim \mathcal{CN}(0, 1)$
```

subscript  $\gamma_{SR} \sim \mathcal{CN}(0, 1)$

```
\begin{displaymath}
\int_{-\infty}^{+\infty} \frac{\sin x}{x} \mathrm{d}x
\end{displaymath}
```

$$\int_0^{+\infty} \frac{\sin x}{x} \mathrm{d}x$$

## MATH USING L<sup>A</sup>T<sub>E</sub>X- SOME MORE

Align equations, piecewise functions? Check!

```
\begin{equation}
u[n] = \begin{cases}
1 & n \geq 0 \\
0 & n < 0
\end{cases}
\end{equation}
```

$$u[n] = \begin{cases} 1 & n \geq 0 \\ 0 & n < 0 \end{cases} \quad (1)$$

## MATH USING L<sup>A</sup>T<sub>E</sub>X- SOME MORE

Align equations, piecewise functions? Check!

```
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0 & n < 0
\end{cases}
\end{equation}
```

$$u[n] = \begin{cases} 1 & n \geq 0 \\ 0 & n < 0 \end{cases} \quad (1)$$

```
\begin{aligned*}
u &= \cos xy \\
\frac{\partial u}{\partial x} &= -y \sin xy
\end{aligned*}
```

$$u = \cos xy$$

$$\frac{\partial u}{\partial x} = -y \sin xy$$

## PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING T<sub>I</sub>K<sub>Z</sub>)

---

Wow, math looks good, but . . .  
. . . can I include it in graphics?

## PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING T<sub>I</sub>K<sub>Z</sub>)

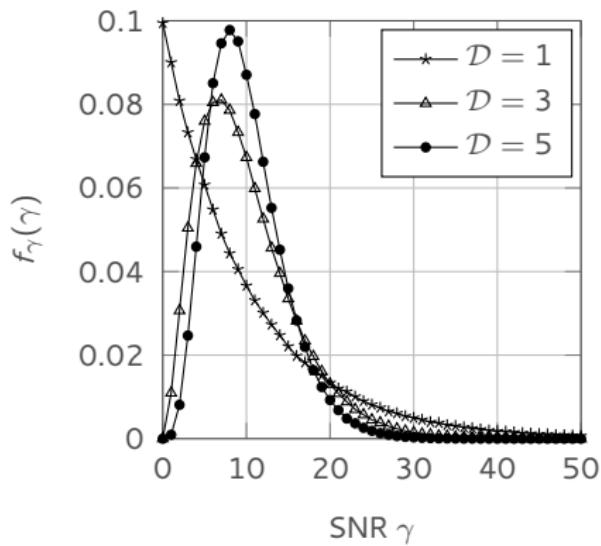
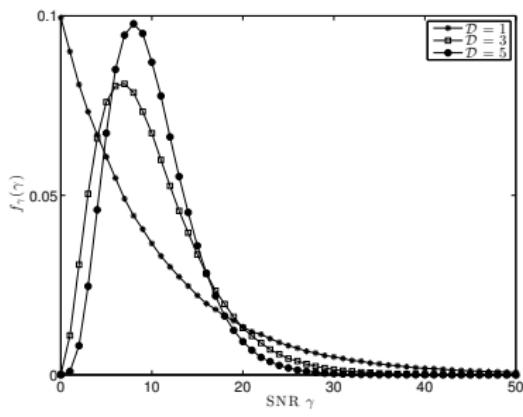
Wow, math looks good, but . . .  
... can I include it in graphics?

**HELL YES**

# PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ)

Wow, math looks good, but . . .  
... can I include it in graphics?

HELL YES



# PLOTTING WITH LATEX(USING TIKZ) - STEP BY STEP EXAMPLE

## Prerequisite

- ▶ Data stored in a text file, column-wise

```
figure();  
hold on;  
plot(x,y);  
plot(x,z);
```

5	5.81	0.57
10	4.72	0.58
15	4.57	0.59
20	4.42	0.59
25	4.11	0.61
30	3.99	0.63
35	3.73	0.64
40	3.78	0.63

Content of data.txt

# PLOTTING WITH LATEX(USING TIKZ) - STEP BY STEP EXAMPLE

## Prerequisite

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figure();	5	5.81	0.57
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Content of data.txt

## PLOTTING WITH LATEX(USING TIKZ) - STEP BY STEP EXAMPLE

### Prerequisite

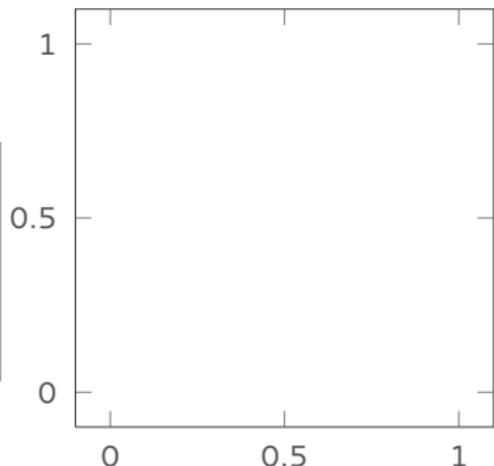
- ▶ Data stored in a text file, column-wise

figure();	5	5.81	0.57
hold on;	10	4.72	0.58
plot(x,y);	15	4.57	0.59
plot(x, <span style="color:red">z</span> );	20	4.42	0.59
	25	4.11	0.61
	30	3.99	0.63
	35	3.73	0.64
	40	3.78	0.63

Content of data.txt

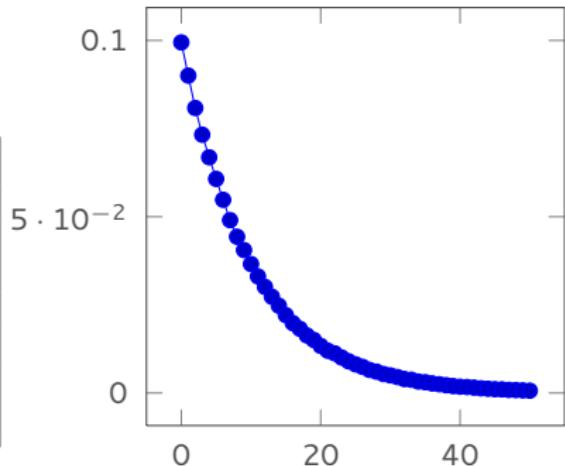
# PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - STEP BY STEP EXAMPLE

```
\begin{tikzpicture}
\begin{axis}[
width=5.5cm, height=5.5cm,
font=\scriptsize ]
\end{axis}
\end{tikzpicture}
```



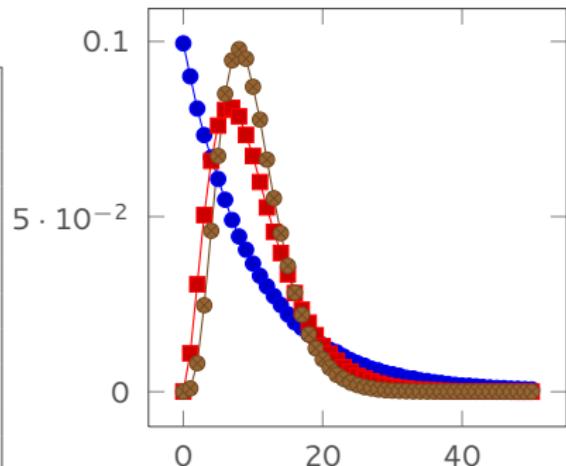
# PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - STEP BY STEP EXAMPLE

```
\begin{tikzpicture}
\begin{axis}[
width=5.5cm, height=5.5cm,
font=\scriptsize ]
\addplot table[x index =0,
y index =1]{Sources/mrc.dat};
\end{axis}
\end{tikzpicture}
```



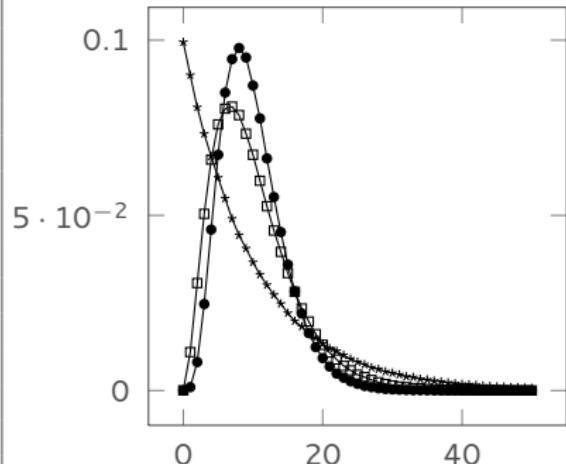
# PLOTTING WITH LATEX(USING TIKZ) - STEP BY STEP EXAMPLE

```
\begin{tikzpicture}
\begin{axis}[
width=5.5cm, height=5.5cm,
font=\scriptsize ]
\addplot table[x index =0,
y index =1]{Sources/mrc.dat};
\addplot table[x index =0,
y index =3]{Sources/mrc.dat};
\addplot table[x index =0,
y index =5]{Sources/mrc.dat};
\end{axis}
\end{tikzpicture}
```



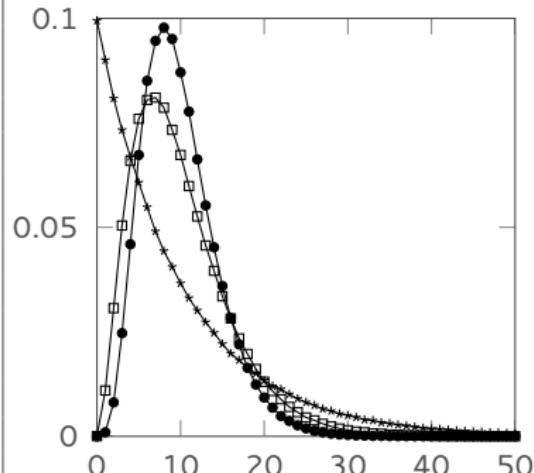
# PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - STEP BY STEP EXAMPLE

```
\begin{tikzpicture}
\begin{axis}[
width=5.5cm, height=5.5cm,
font=\scriptsize ]
\addplot [color=black, mark=star, mark
options={scale=.6}] table[x index =0,
y index =1,] {Sources/mrc.dat};
\addplot [color=black, mark=square, mark
options={scale=.6}] table[x index =0,
y index =3,] {Sources/mrc.dat};
\addplot [color=black, mark=*, mark
options={scale=.6}] table[x index =0,
y index =5,] {Sources/mrc.dat};
\end{axis}
\end{tikzpicture}
```



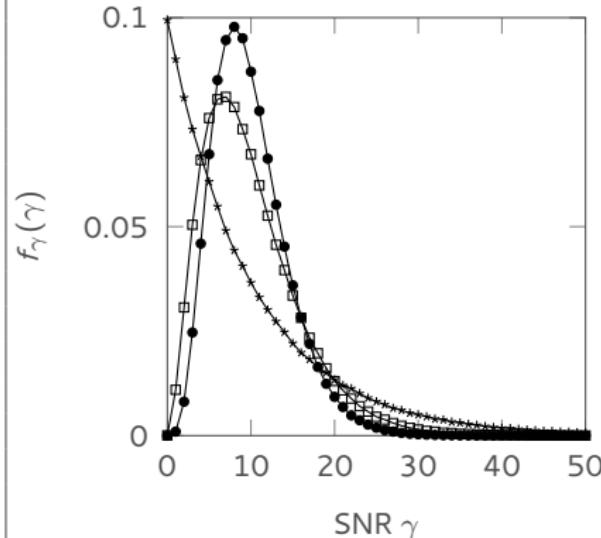
# PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - STEP BY STEP EXAMPLE

```
\begin{tikzpicture}
\begin{axis}[
width=5.5cm, height=5.5cm,
xmin=0, xmax=50, ymin=0,ymax=.1,
xtick={0,10,...,50}, ytick={0,0.05,0.1},
xticklabels={0,10,...,50},
yticklabels={0,0.05,0.1},
font=\scriptsize ]
\addplot [color=black, mark=star, mark
options={scale=.6}] table[x index =0,
y index =1,] {Sources/mrc.dat};
\addplot [color=black, mark=square, mark
options={scale=.6}] table[x index =0,
y index =3,] {Sources/mrc.dat};
\addplot [color=black, mark=*, mark
options={scale=.6}] table[x index =0,
y index =5,] {Sources/mrc.dat};
\end{axis}
\end{tikzpicture}
```



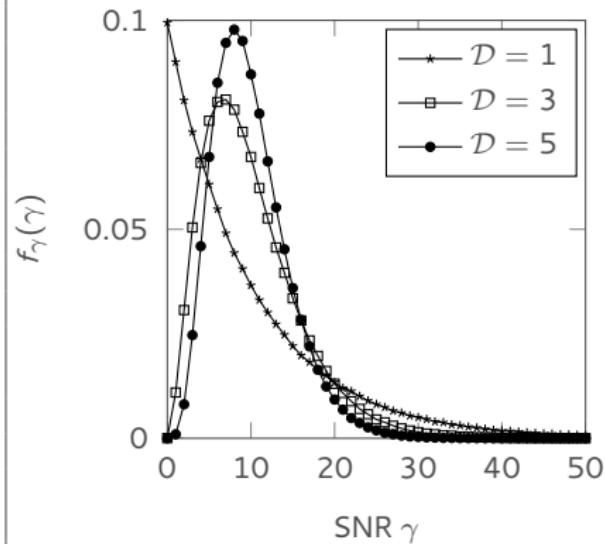
# PLOTTING WITH LATEX(USING TIKZ) - STEP BY STEP EXAMPLE

```
\begin{tikzpicture}
\begin{axis}[
width=5.5cm, height=5.5cm,
xlabel={SNR  $\gamma$ },
ylabel={$f_\gamma(\gamma)$},
xmin=0, xmax=50, ymin=0, ymax=.1,
xtick={0,10,...,50}, ytick={0,0.05,0.1},
xticklabels={0,10,...,50},
yticklabels={0,0.05,0.1},
font=\scriptsize ]
\addplot [color=black, mark=star, mark
options={scale=.6}] table[x index =0,
y index =1,] {Sources/mrc.dat};
\addplot [color=black, mark=square, mark
options={scale=.6}] table[x index =0,
y index =3,] {Sources/mrc.dat};
\addplot [color=black, mark=*, mark
options={scale=.6}] table[x index =0,
y index =5,] {Sources/mrc.dat};
\end{axis}
\end{tikzpicture}
```



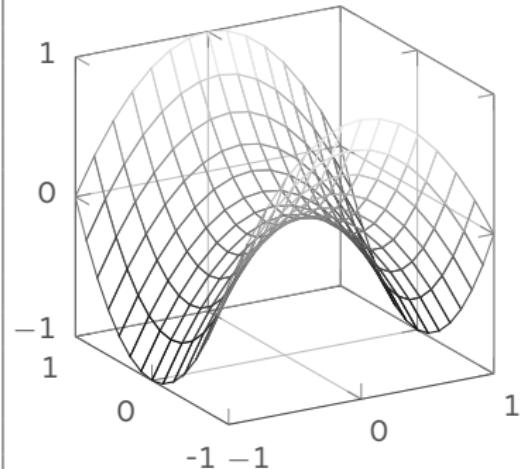
# PLOTTING WITH LATEX(USING TIKZ) - STEP BY STEP EXAMPLE

```
\begin{tikzpicture}
\begin{axis}[
width=5.5cm, height=5.5cm,
xlabel={SNR  $\gamma$ },
ylabel={ $f_\gamma(\gamma)$ },
xmin=0, xmax=50, ymin=0,ymax=.1,
xtick={0,10,...,50}, ytick={0,0.05,0.1},
xticklabels={0,10,...,50},
yticklabels={0,0.05,0.1},
font=\scriptsize ]
\addplot [color=black, mark=star, mark
options={scale=.6}] table[x index =0,
y index =1,] {Sources/mrc.dat};
\addlegendentry{  $\mathcal{D} = 1$  }
\addplot [color=black, mark=square, mark
options={scale=.6}] table[x index =0,
y index =3,] {Sources/mrc.dat};
\addlegendentry{  $\mathcal{D} = 3$  }
\addplot [color=black, mark=*, mark
options={scale=.6}] table[x index =0,
y index =5,] {Sources/mrc.dat};
\addlegendentry{  $\mathcal{D} = 5$  }
\end{axis}
\end{tikzpicture}
```



# PLOTTING WITH LATEX(USING TIKZ) - 3D

```
\begin{tikzpicture}
\begin{axis}[
view={60}{20}, grid=both,
width=5.5cm,height=5.5cm,
xmin=-1, xmax=1,
ymin=-1, ymax=1,
zmin=-1, zmax=1,
x dir=reverse,
xtick={-1,0,1},
xticklabels={-1,0,1},
font=\scriptsize]
\addplot3
[mesh, colormap/blackwhite,
samples=15, domain=-1:1]
{x^2 - y^2};
\end{axis}
\end{tikzpicture}
```



## PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - FLOW CHART

```
\begin{tikzpicture}
\end{tikzpicture}
```

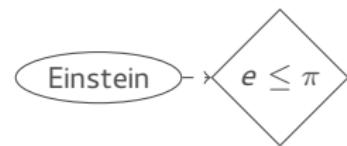
## PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - FLOW CHART

```
\begin{tikzpicture}
\tikzstyle{every node}=[font=\scriptsize,
inner sep=2pt]
\node [draw, diamond]
(q1) {$e \leq \pi$};
\end{tikzpicture}
```



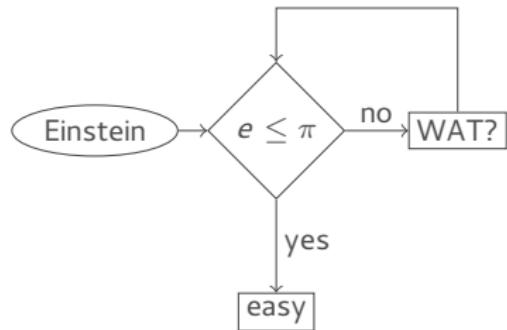
## PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING T<sub>I</sub>K<sub>Z</sub>) - FLOW CHART

```
\begin{tikzpicture}[node distance=1.7cm,
    auto]
\tikzstyle{every node}=[font=\scriptsize,
    inner sep=2pt, draw]
\node[diamond]
(q1) {$e \leq \pi$};
\node[ellipse, left of=q1]
(ein) {Einstein};
\draw[dashed, ->] (ein) -- (q1);
\end{tikzpicture}
```



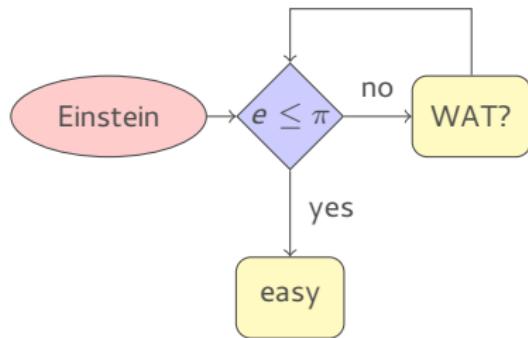
# PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - FLOW CHART

```
\begin{tikzpicture}[node distance=1.7cm,
    auto]
\tikzstyle{every node}=[font=\scriptsize,
    inner sep=2pt]
\node[draw, diamond]
    (q1) {$e \leq \pi$};
\node[draw, ellipse, left of=q1]
    (ein) {Einstein};
\draw[->] (ein) -- (q1);
\node[draw, rectangle, below of=q1]
    (ok) {easy};
\draw[draw, ->] (q1) -- node {yes} (ok);
\node[draw, rectangle, right of=q1]
    (wat) {WAT?};
\draw[->] (q1) -- node {no} (wat);
\draw[->] (wat.north) |- 
    ([yshift=0.5cm]q1.north) -- (q1.north);
\end{tikzpicture}
```



# PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - FLOW CHART

```
\begin{tikzpicture}[node distance=1.7cm,
    auto]
\tikzstyle{every node}=[font=\scriptsize]
\tikzstyle{dec}=[diamond, draw,
    fill=blue!20, inner sep=0pt]
\tikzstyle{bl}=[rectangle, align=center,
    draw, rounded corners, minimum width=2em,
    fill=yellow!30, minimum height=1.5em]
\tikzstyle{cl}=[draw, ellipse,
    fill=red!20, minimum height=1.5em]
\node[dec, diamond] (q1) {$e \leq \pi$};
\node[cl, left of=q1] (ein) {Einstein};
\draw[->] (ein) -- (q1);
\node[bl, below of=q1] (ok) {easy};
\draw[draw, ->] (q1) -- node {yes} (ok);
\node[bl, right of=q1] (wat) {WAT?};
\draw[->] (q1) -- node {no} (wat);
\draw[->] (wat.north) |- ([yshift=0.5cm]q1.north) -- (q1.north);
\end{tikzpicture}
```



## PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - TCP FRAME EXCHANGE

```
\begin{tikzpicture}[auto]
\tikzstyle{every node}=[font=\scriptsize]
\newcommand{\ww}{4}; \newcommand{\len}{-4};
\draw[->] (0,0) -- ++(0,\len);
\draw[->] (\ww,0) -- ++(0,\len);
\end{tikzpicture}
```



# PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - TCP FRAME EXCHANGE

```
\begin{tikzpicture}[auto]
\tikzstyle{every node}=[font=\scriptsize]
\newcommand{\ww}{4}; \newcommand{\len}{-4};
\draw[->] (0,0) -- ++(0,\len)
node[anchor=north] {t};
\draw[->] (\ww,0) -- ++(0,\len)
node[anchor=north] {t};
\end{tikzpicture}
```

↓  
t

↓  
t

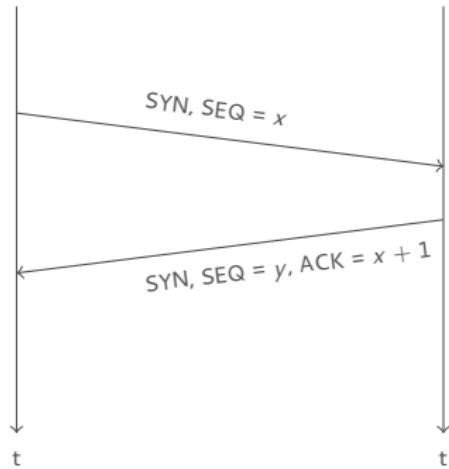
# PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - TCP FRAME EXCHANGE

```
\begin{tikzpicture}[auto]
\tikzstyle{every node}=[font=\scriptsize]
\newcommand{\ww}{4}; \newcommand{\len}{-4};
\draw[->] (0,0) -- ++(0,\len)
node[anchor=north] {t};
\draw[->] (\ww,0) -- ++(0,\len)
node[anchor=north] {t};
\draw[->] (0,-1) -- ++(\ww,-0.5)
node[near start, sloped] {SYN, SEQ = $x$};
\end{tikzpicture}
```



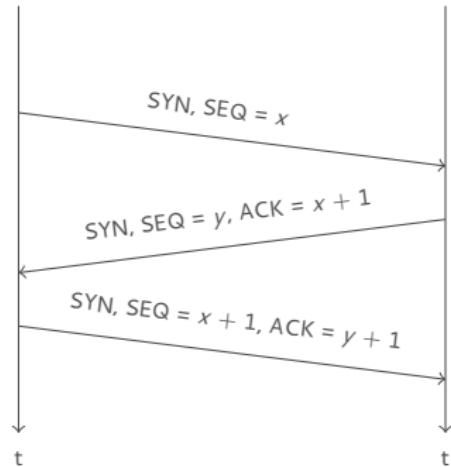
# PLOTTING WITH LATEX(USING TIKZ) - TCP FRAME EXCHANGE

```
\begin{tikzpicture}[auto]
\tikzstyle{every node}=[font=\tiny]
\newcommand{\ww}{4}; \newcommand{\len}{-4};
\draw[->] (0,0) -- +(0,\len)
node[anchor=north] {t};
\draw[->] (\ww,0) -- +(0,\len)
node[anchor=north] {t};
\draw[->] (0,-1) -- +(\ww,-0.5)
node[near start, sloped] {SYN, SEQ = $x$};
\draw[->] (\ww,-2) -- +(-\ww,-0.5)
node[near end, sloped]
{SYN, SEQ = $y$, ACK = $x+1$};
\end{tikzpicture}
```



# PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - TCP FRAME EXCHANGE

```
\begin{tikzpicture}[auto]
\tikzstyle{every node}=[font=\tiny]
\newcommand{\ww}{4}; \newcommand{\len}{-4};
\draw[->] (0,0) -- ++(0,\len)
node[anchor=north] {t};
\draw[->] (\ww,0) -- ++(0,\len)
node[anchor=north] {t};
\draw[->] (0,-1) -- ++(\ww,-0.5)
node[near start, sloped] {SYN, SEQ = $x$};
\draw[->] (\ww,-2) -- ++(-\ww,-0.5)
node[midway, sloped, above]
{SYN, SEQ = $y$, ACK = $x+1$};
\draw[->] (0,-3) -- ++(\ww,-0.5)
node[midway, sloped, above]
{SYN, SEQ = $x+1$, ACK = $y+1$};
\end{tikzpicture}
```



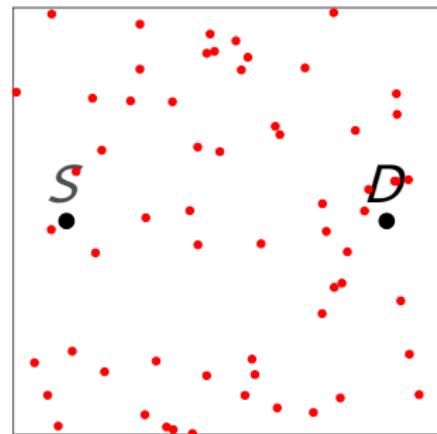
# PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - RANDOM COORDINATES

```
\begin{tikzpicture}[]
\draw (0,0) rectangle (4,4);
\tikzstyle{sd}=[black, draw, circle,
minimum size=4pt, inner sep=0pt, fill]
\tikzstyle{i}=[red, draw, circle,
minimum size=2pt, inner sep=0pt, fill]
% source
\node[sd] at (0.5,2) (s) {};
\node[anchor=south] at (s) {$S$};
% destination
\node[sd] at (3.5,2) (d) {};
\node[black, anchor=south] at (d) {$D$};
\end{tikzpicture}
```



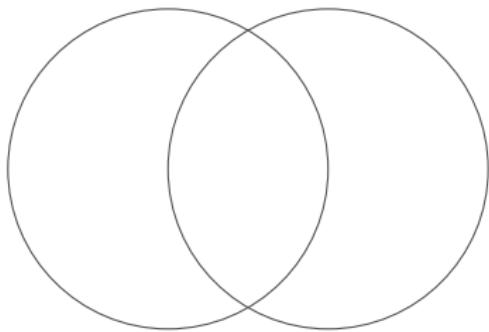
# PLOTTING WITH LATEX(USING TIKZ) - RANDOM COORDINATES

```
\begin{tikzpicture}[]
\draw (0,0) rectangle (4,4);
\tikzstyle{sd}=[black, draw, circle,
minimum size=4pt, inner sep=0pt, fill]
\tikzstyle{i}=[red, draw, circle,
minimum size=2pt, inner sep=0pt, fill]
% source
\node[sd] at (0.5,2) (s) {};
\node[anchor=south] at (s) {$S$};
% destination
\node[sd] at (3.5,2) (d) {};
\node[black, anchor=south] at (d) {$D$};
% interferers
\foreach \i in {0,1,...,60} {
    \node[i] at (4 * rnd, 4 * rnd) {};
}
\end{tikzpicture}
```



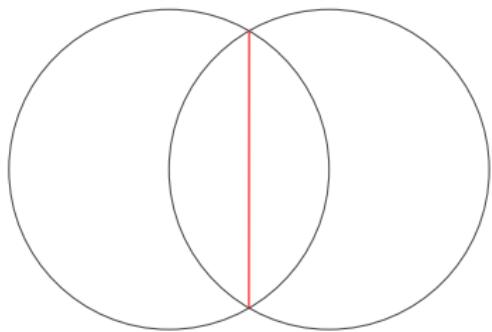
## PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - INTERSECTIONS

```
\begin{tikzpicture}
    \coordinate (A) at (1,0);
    \coordinate (B) at (2.5,0);
    \node [name path=C, draw,
        circle through=(A)] at (B) {};
    \node [name path=D, draw,
        circle through=(B)] at (A) {};
\end{tikzpicture}
```



## PLOTTING WITH L<sup>A</sup>T<sub>E</sub>X(USING TIKZ) - INTERSECTIONS

```
\begin{tikzpicture}
\coordinate (A) at (1,0);
\coordinate (B) at (2.5,0);
\node [name path=C, draw,
       circle through=(A)] at (B) {};
\node [name path=D, draw,
       circle through=(B)] at (A) {};
\path [name intersections={of=C and D}];
\draw [red] (intersection-1) --
           (intersection-2);
\end{tikzpicture}
```



## AND NOW?

---

- ▶ If you liked what you saw, **use TikZ**
- ▶ Can I draw \$(crazy stuff)? **Very likely**
- ▶ How?

AND NOW?

- ▶ If you liked what you saw, **use TikZ**
- ▶ Can I draw \$(crazy stuff)? **Very likely**
- ▶ How?



- ▶ <http://www.texample.net/tikz/>

# Thanks a lot

If you liked it, and you want the code:

<https://alexcriss@bitbucket.org/alexcriss/plotting-in-latex>