A brief introduction into TikZ

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- What is TikZ?
- How to draw figures?
- How to place text inside the figures?

"Logic is everywhere ..."

These slides are based on slides of Tobias Pietzsch
PGF and TikZ

- PGF (portable graphics format)
  - package for creating graphics “inline”
  - \TeX\ and \LaTeX\ input
  - PDF, PostScript, and SVG output
  - three layers: System, Basic, and Frontend

- TikZ (TikZ is not a drawing program)
  - is a PGF frontend layer.
  - high-level user interface.
  - Current version 2.00 is quite old (February 2008)
  - For features and bug-fixes: http://www.texample.net/tikz/builds/

- written by Till Tantau (author of Beamer package) and Mark Wibrow.
Setup your environment

► Use a \LaTeX\ document

► Use the TikZ package and required TikZ libraries

\usepackage{tikz}
\usetikzlibrary{...}

► Draw TikZ figure in the document.

\begin{tikzpicture}
  \draw (0,0) circle (0.5);
  \draw (-0.5,-0.5) -- (0.5,0.5);
\end{tikzpicture}

\tikz \draw (0,0) circle (0.5);
Setup your environment

► Use a \LaTeX\ document

► Use the Ti\textit{k}Z package and required Ti\textit{k}Z libraries

\usepackage{tikz}
\usetikzlibrary{...}

► Draw Ti\textit{k}Z figure in the document.

\begin{tikzpicture}
  \draw (0,0) circle (0.5);
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\tikz \draw (0,0) circle (0.5);
Setup your environment

- Use a LaTeX document
- Use the TikZ package and required TikZ libraries

\begin{tikzpicture}
  \draw (0,0) circle (0.5);
  \draw (-0.5,-0.5) -- (0.5,0.5);
\end{tikzpicture}

\tikz \draw (0,0) circle (0.5);
A path is a series of straight and curved line segments.

Syntax:

\path (path-operation | graphic-option)* ;

There are two major operations: draw and node.

\draw is an abbreviation for \path [draw]

Next, drawing figures by using \draw is presented.

By using \node text is added afterwards.
Drawing with paths

A step by step example for `\draw`:

\begin{tikzpicture}
\path [draw] (0,0) circle (0.5)
(-0.5,-0.5) -- (0.5,0.5);
\end{tikzpicture}
Drawing with paths

▶ A step by step example for \draw:

\begin{tikzpicture}
\path [draw] (0,0) circle (0.5)
(-0.5,-0.5) -- (0.5,0.5) ;
\end{tikzpicture}

▶ Move-To Operation: move to coordinate \((0,0)\)
▶ without drawing anything
Drawing with paths

A step by step example for \draw:

\begin{tikzpicture}
\path [draw] (0,0) circle (0.5)
(-0.5,-0.5) -- (0.5,0.5) ;
\end{tikzpicture}

Circle Operation: draw circle with radius (0.5)

current point remains (0,0)


Drawing with paths

▶ A step by step example for \draw:

\begin{tikzpicture}
\path [draw] (0,0) circle (0.5)
(-0.5,-0.5) -- (0.5,0.5) ;
\end{tikzpicture}

▶ Move-To Operation: move to coordinate \((-0.5,-0.5)\)

▶ without drawing anything
Drawing with paths

► A step by step example for \texttt{\textbackslash draw}:

\begin{tikzpicture}
\path [draw] (0,0) circle (0.5)
(-0.5,-0.5) -- (0.5,0.5) ;
\end{tikzpicture}

► Line-To Operation: line to coordinate \texttt{(0.5,0.5)}
A step by step example for \draw:

\begin{tikzpicture}
\path [draw] (0,0) circle (0.5)
(-0.5,-0.5) -- (0.5,0.5) ;
\end{tikzpicture}

Path ends.
Graphic Options

► Add color and line styles to the picture:

\begin{tikzpicture}
  \draw (0,0) circle (0.5);
  \draw (-0.5,-0.5) -- (0.5,0.5);
\end{tikzpicture}
Graphic Options

► Add color and line styles to the picture:

\begin{tikzpicture}
\draw [color=blue] (0,0) circle (0.5);
\draw (-0.5,-0.5) -- (0.5,0.5);
\end{tikzpicture}

► Add color to the line.
Graphic Options

► Add color and line styles to the picture:

\begin{tikzpicture}
\draw [color=blue, fill=blue!20!white] (0,0) circle (0.5);
\draw (-0.5,-0.5) -- (0.5,0.5);
\end{tikzpicture}

► Fill the circle with color.
Graphic Options

- Add color and line styles to the picture:

```latex
\begin{tikzpicture}
  \draw [color=blue, fill=blue!20!white, fill opacity=0.6]
  (0,0) circle (0.5);
  \draw (-0.5,-0.5) -- (0.5,0.5);
\end{tikzpicture}
```

- Make circle transparent.
Graphic Options

► Add color and line styles to the picture:

\begin{tikzpicture}
\draw [color=blue, fill=blue!20!white, fill opacity=0.6]
(0,0) circle (0.5);
\draw [thick] (-0.5,-0.5) -- (0.5,0.5);
\end{tikzpicture}

► Draw a thick line.
Graphic Options

▶ Add color and line styles to the picture:

\begin{tikzpicture}
  \draw [color=blue, fill=blue!20!white, fill opacity=0.6] (0,0) circle (0.5);
  \draw [thick, dashed] (-0.5,-0.5) -- (0.5,0.5);
\end{tikzpicture}

▶ Draw a dashed line.
Graphic Options

▶ Add color and line styles to the picture:

\begin{tikzpicture}
  \draw [color=blue, fill=blue!20!white, fill opacity=0.6] (0,0) circle (0.5);
  \draw [thick, dashed, ->] (-0.5,-0.5) -- (0.5,0.5);
\end{tikzpicture}

▶ Draw an arrow.
Graphic Options

- Add color and line styles to the picture:

\begin{tikzpicture}
  \draw [color=blue, fill=blue!20!white, fill opacity=0.6] (0,0) circle (0.5);
  \draw [thick, dashed, ->, rotate=30] (-0.5,-0.5) -- (0.5,0.5);
\end{tikzpicture}

- Rotate the arrow.
Scoping and Grouping Graphic Options

▶ Grouping multiple graphic options:

\begin{tikzpicture}
  \draw [orange, very thick] (0,0) circle (0.5);
  \draw [orange, very thick](-0.5,-0.5) -- (0.5,0.5);
  \draw [orange, very thick](0.5,-0.5) -- (-0.5,0.5);
\end{tikzpicture}
Scoping and Grouping Graphic Options

▶ Grouping multiple graphic options:

\begin{tikzpicture} [orange, very thick]
\draw (0,0) circle (0.5);
\draw(-0.5,-0.5) -- (0.5,0.5);
\draw(0.5,-0.5) -- (-0.5,0.5);
\end{tikzpicture}

▶ Define a set of options for the whole figure.
Scoping and Grouping Graphic Options

▶ Grouping multiple graphic options:

\begin{tikzpicture}
\draw (0,0) circle (0.5);
\begin{scope} [orange, very thick]
\draw(-0.5,-0.5) -- (0.5,0.5);
\draw(0.5,-0.5) -- (-0.5,0.5);
\end{scope}
\end{tikzpicture}

▶ Set a scope.

\begin{tikzpicture}
\draw (0,0) circle (0.5);
\begin{scope} [orange, very thick]
\draw(-0.5,-0.5) -- (0.5,0.5);
\draw(0.5,-0.5) -- (-0.5,0.5);
\end{scope}
\end{tikzpicture}
Grouping multiple graphic options:

\begin{tikzpicture}
  [marked/.style = {orange, very thick}]
  \draw (0,0) circle (0.5);
  \draw [marked] (-0.5,-0.5) -- (0.5,0.5);
  \draw [marked] (0.5,-0.5) -- (-0.5,0.5);
\end{tikzpicture}

Define a style.
Scoping and Grouping Graphic Options

▶ Grouping multiple graphic options:

```latex
\tikzset{marked/.style = {orange, very thick}}
\begin{tikzpicture}
  \draw (0,0) circle (0.5);
  \draw [marked] (-0.5,-0.5) -- (0.5,0.5);
  \draw [marked] (0.5,-0.5) -- (-0.5,0.5);
\end{tikzpicture}
```

▶ Draw a global style.
Scoping and Grouping Graphic Options

- Grouping multiple graphic options:

\begin{tikzpicture}
\t\draw (0,0) circle (0.5);
\t\draw [marked,blue] (-0.5,-0.5) -- (0.5,0.5);
\t\draw [marked,dashed] (0.5,-0.5) -- (-0.5,0.5);
\end{tikzpicture}

- Properties of styles can be overwritten.
Coordinates

- There exists multiple coordinate systems
  - Polar coordinates are not introduced here
- Absolute coordinates
  \[ \texttt{tikz \ draw [thick,red] (0,0) -- (2mm, 0) -- (2mm, 5pt);} \]
- Relative coordinates
  \[ \texttt{tikz \ draw [thick,red] (0,0) -- +(2mm, 0) -- +(0, 5pt);} \]
- Named points
  \[ \texttt{tikz \ draw [thick,red] (0,0) -- ++(2mm, 0) -- +(0, 5pt);} \]
- Named points
  \[ \texttt{tikz \ draw [thick,red] (10mm,1mm) coordinate (c1) circle (5pt)
           (0,0) -- (c1);} \]
Nodes

- A node is a simple shape with some text on it.

\begin{tikzpicture}
\node[shape=circle, draw, color=red] {hello};
\end{tikzpicture}

- Constructed using the path-operation \textit{node}.
- \texttt{path node} can be abbreviated as \texttt{node}.
- \texttt{shape=} and \texttt{color=} can be omitted if there is no confusion.
Nodes

- A node is a simple shape with some text on it.

```latex
\tikz \node [circle, draw, red] {hello};
```

- Constructed using the path-operation \textit{node}.
- \textit{\textbackslash path node} can be abbreviated as \textit{\textbackslash node}.
- \textit{shape=} and \textit{color=} can be omitted if there is no confusion.
Node Syntax

\texttt{\textbackslash path ... node [options] (name) at (coordinate) \{contents\} \textellipsis}
Node Syntax

\path ... node [options] (name) at (coordinate) \{contents\} ...;

- options may contain node shape, color, sizes, labels, ...
- A node may get a name for later reference.
- A node may be placed using at (coordinate).
  (Otherwise it is placed at the current path coordinate.)
- Nodes contents can be arbitrary \LaTeX.
Node Syntax

\path ... node \[options\] \ (name) \ at \ (coordinate) \ \{contents\} ...;

- \textit{options} may contain node shape, color, sizes, labels, ...
- A node may get a \textit{name} for later reference.
- A node may be placed using \textit{at (coordinate)}.
  (Otherwise it is placed at the current path coordinate.)
- Nodes \textit{contents} can be arbitrary \texttt{LaTeX}.

\texttt{TikZ} is quite liberal with respect to the order of the arguments.

\begin{tikzpicture}
\node [circle, draw=red] (hello) at (0,0) {hello};
\end{tikzpicture}
Placing Nodes

\begin{tikzpicture}
  \node [packet] (p1) at (0,0.5) {$p_1$};
  \node [packet] (p1) at (1,0.5) {$p_1$};
  \node [packet] (p1) at (4,0.5) {$p_1$};
  \node [packet] (p1) at (0,0.5) {$p_n$};
\end{tikzpicture}

\begin{itemize}
  \item Can be placed at absolute positions.
\end{itemize}
Placing Nodes

\begin{tikzpicture}
  \node [packet] (p1) at (0,0.5) {$p_1$};
  \node [packet,right=0.25 of p1] (p2) {$p_2$};
  \node [packet,right=2 of p2] (pn) {$p_n$};
\end{tikzpicture}

▷ Relative placement allows to say things like:
  ▷ “Node (p2) should be right of (p1)” (wherever (p1) happens to be).
  ▷ Requires the \texttt{positioning} TikZ library:
    \texttt{usetikzlibrary{positioning}}
  ▷ available: right=of, below=of, above left=of, ...

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Connecting Nodes

- We can simply draw paths between node anchors.

\begin{tikzpicture} [>=latex']
\node [circle, draw] (a) {a};
\node [circle, draw] (b) [above right=of a] {b};
\draw [->] (a.east) -- (b.west);
\end{tikzpicture}

- Each node has anchors, e.g. east, west, center, …
Connecting Nodes

► We can simply draw paths between node anchors.

\usetikzlibrary{arrows}

\begin{tikzpicture}[>=latex']
   \node [circle, draw] (a) {a};
   \node [circle, draw] (b) [above right=of a] {b};
   \draw [->] (a) -- (b);
\end{tikzpicture}

► Each node has anchors, e.g. east, west, center, …

► If anchor specifications are left out TikZ tries to be smart about the anchor it should choose.
Connecting Nodes

▶ We can simply draw paths between node anchors.

```latex
\usetikzlibrary{arrows}
\begin{tikzpicture}[>=latex']
    \node [circle, draw] (a) {a};
    \node [circle, draw] (b) [above right=of a] {b};
    \draw [->] (a) -| (b);
\end{tikzpicture}
```

▶ Each node has anchors, e.g. `east`, `west`, `center`, ...

▶ If anchor specifications are left out TikZ tries to be smart about the anchor it should choose.

▶ Another path operation `-|`

▶ Again, TikZ is clever about the correct anchors
A very powerful path operation is to:

\begin{tikzpicture} [>=latex']
    \node [circle, draw] (a) at (0,0) {a};
    \node [circle, draw] (b) at (1,1) {b};
    \draw [->] (a) to (b);
\end{tikzpicture}
Connecting Nodes

A very powerful path operation is to.

\begin{tikzpicture} [>=latex']
  \node [circle, draw] (a) {a};
  \node [circle, draw] (b) [above right=of a] {b};
  \draw [->] (a) to [bend left=45] (b);
\end{tikzpicture}
Connecting Nodes

A very powerful path operation is to.

\begin{tikzpicture}[>=latex']
  \node [circle, draw] (a) {a};
  \node [circle, draw] (b) [above right=of a] {b};
  \draw [->] (a) to [out=0, in=180] (b);
\end{tikzpicture}
Connections can be labeled by inserting text nodes in the path.

\begin{tikzpicture}
    \node [circle, draw] (a) at (0,0) {a};
    \node [circle, draw] (b) at (1,1) {b};
    \draw [->] (a) to [bend left=45] (b);
\end{tikzpicture}
Labeling Connections

Connections can be labeled by inserting text nodes in the path.

\begin{tikzpicture}
  \node [circle, draw] (a) {a};
  \node [circle, draw] (b) [above right=of a] {b};
  \draw [-{Latex[angle=45:2pt 3]}] (a) to [bend left=45] node [auto] {$f$} (b);
\end{tikzpicture}

The `auto` option places the label such that it is next to the path and doesn’t overlap anything. The `swap` places the label on the other side of the path. Instead of `auto`, also `left`, `above`, `right`, and `below` can be used.
Labeling Connections

- Connections can be labeled by inserting text nodes in the path.

\begin{tikzpicture}
    \node [circle, draw] (a) {a};
    \node [circle, draw] (b) [above right=of a] {b};
    \draw [->] (a) to [bend left=45] node [auto] {$f$} (b);
\end{tikzpicture}

- The \texttt{auto} option places the label such that it is next to the path and doesn't overlap anything.
Labeling Connections

- Connections can be labeled by inserting text nodes in the path.

\begin{tikzpicture}
  \node [circle, draw] (a) {a};
  \node [circle, draw] (b) [above right=of a] {b};
  \draw [->] (a) to [bend left=45] node [auto,swap] {$f$} (b);
\end{tikzpicture}

- The `auto` option places the label such that it is next to the path and doesn’t overlap anything.

- `swap` places the label on the other side of the path.
Labeling Connections

- Connections can be labeled by inserting text nodes in the path.

\begin{tikzpicture}
  \node [circle, draw] (a) {a};
  \node [circle, draw] (b) [above right=of a] {b};
  \draw [-] (a) to [bend left=45] node [left] \(f\) (b);
\end{tikzpicture}

- The **auto** option places the label such that it is next to the path and doesn’t overlap anything.

- **swap** places the label on the other side of the path.

- Instead of **auto**, also **left**, **above**, **right** and **below** can be used.
For Loop

- For drawing multiple objects a for loop can be used
- Loops can be nested

\begin{tikzpicture}
\foreach \y in {1,2,3} {
    \draw [blue, ultra thick] (0,\y) circle [radius=0.3];
}\end{tikzpicture}
Good Practice

- Place nodes relative to each other
- Do not use too many colors and styles
- Do not overload figures.

Further information:
- **Gnuplot** has a **TikZ** terminal
- **Inkscape** can export to **TikZ**
- **Dia** is another GUI that can export **TikZ**
- **see** [http://www.texample.net/tikz/resources/](http://www.texample.net/tikz/resources/)