Creating Graphics from Scratch

Case Studies

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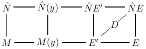
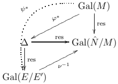
Outline

A Page From a gtem Publication with a Figure.

particular D is regular over M. Also $\Delta \cap A = \Delta \cap \nu(A) = 1$, so $DE = D\hat{N} = \hat{N}E$.



Choose a Galois ring cover $\hat{S}/R$ of $\hat{N}E/M(y)$ [FJ05, Definition 6.1.3 and Remark 6.1.5] such that $y \in R$ and $x \in \hat{S}$. Let $U = \hat{S} \cap D$. The ring extension U/R corresponds to a dominating separable rational map $\mathrm{Spec}(U) \to \mathrm{Spec}(R)$. Since the quotient field of R is a rational function field, $\mathrm{Spec}(R)$ is an open subvariety of an affine space. Therefore, by the definition of PAC extensions we have an M-epimorphism $\varphi\colon U \to M$ with $\alpha = \varphi(y) \in F$. The field D is regular over M and $D\hat{N} = \hat{N}E$, hence $\hat{S} = U \otimes_M \hat{N}$ [FJ05, Lemma 2.5.10]. Extend φ to an $\hat{N}$-epimorphism $\varphi\colon \hat{S} \to \hat{N}$. Then, φ induces a homomorphism $\varphi^*\colon \mathrm{Gal}(M) \to \mathrm{Gal}(\hat{N}E/D)$ which satisfies $\mathrm{res}_{\hat{N}E,\hat{N}} \circ \varphi^* = \mathrm{res}_{M_s,\hat{N}}$, where M_s is a separable closure of M [FJ05, Lemma 6.1.4]. Let ψ be the restriction of φ to $S = \hat{S} \cap E$. The equality $DE = \hat{N}E$ implies that $\hat{S}$ is a subring of the quotient field of SU. Since $\psi(\hat{S}) = \hat{N}$ and $\psi(U) = M$ it follows that $\psi(S) = \hat{N}$ and $\psi^* = \mathrm{res}_{\hat{N}E,E} \circ \varphi^*$. From the commutative diagram



it follows that $(\psi^*)^{-1}(\nu(A_0)) = \mathrm{res}^{-1}_{M_s,\hat{N}}(\mathrm{Gal}(\hat{N}/N)) = \mathrm{Gal}(N)$. Consequently, the residue field of $E'(x)$ under ψ is N. Also $E' \subseteq D$ implies that the residue field of E' is M. Consequently, $N = M(\beta)$, where $\beta = \psi(x)$ is a root of $f(X, \alpha)$. Finally, since $[N : M] = n$, the polynomial $f(X, \alpha)$ is irreducible over M.

To complete the proof we need to find infinitely many $\alpha \in F$ as above. This is done by the 'Rabinovich trick', that is, we replace R by the localization of R at $\prod_{i=1}^{n}(y - \alpha_i)$ (see [JR94, Remark 1.2(c)]). □

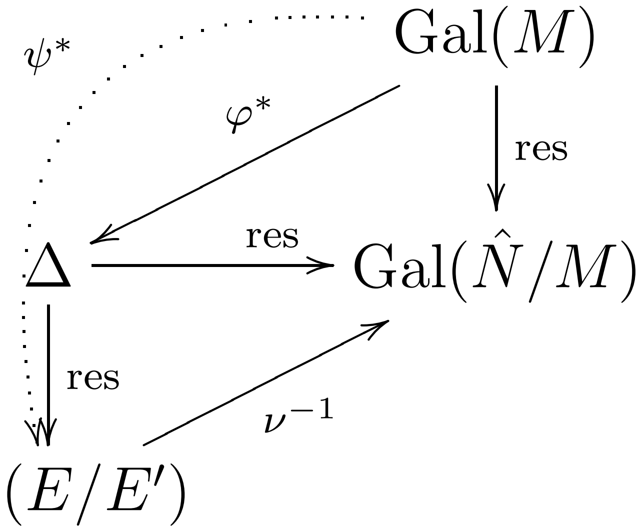
Corollary 2. *Let M/F be a PAC extension, let $f(X, y) \in M[X, y]$ be a polynomial of degree n in X, and let N/M be a separable extension of degree n. Assume that the Galois*

Bary-Soroker Lior

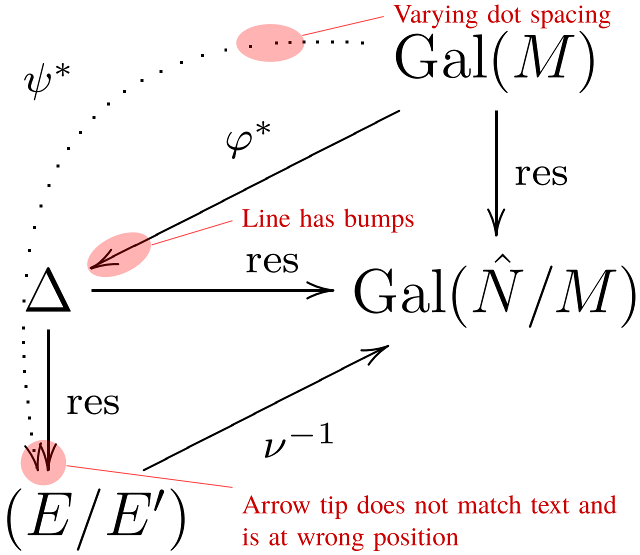
Dirichlet's Theorem For Polynomial Rings

arXiv:math/0612801v2

Closeup of the Figure

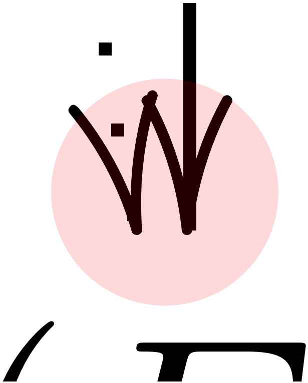


Critique

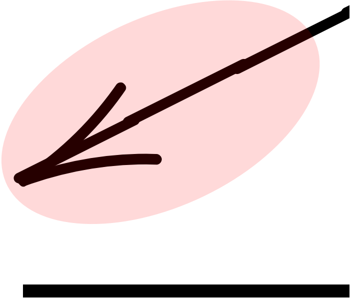


Varying dot spacing
$\mathrm{Gal}(M)$
ψ^*
φ^*
res
Line has bumps
res
Δ
$\mathrm{Gal}(\hat{N}/M)$
res
ν^{-1}
(E/E')
Arrow tip does not match text and is at wrong position

Closeups Of the Problematic Areas.



Arrow tip does not match text and is at wrong position



Line has bumps

Step 1: Creating the Nodes.

Basic Idea

To (re)create the figure in Ti*k*Z, we start with the nodes, which are created using the `node` command.

Syntax of the Node Creation Command

- Start with `\node`.
- Then comes a sequences of options.
- Options are given in square brackets, with two exceptions:
  We can say `at` ⟨coordinate⟩ to specify a special place, where the node should go.
  We can say ⟨name⟩ to assign a name to a node.
- The node ends with some text in curly braces.

Step 1: Creating the Nodes.

A Simple Placement

$\mathrm{Gal}(M)$

Δ $\qquad\qquad$ $\mathrm{Gal}(\hat N/M)$

(E/E')

```
\begin{tikzpicture}
  \node (EE)    at (0,0)   {$(E/E')$};
  \node (Delta) at (0,1.5) {$\Delta$};
  \node (GalNM) at (3,1.5) {$\mathrm{Gal}(\hat N/M)$};
  \node (GalM)  at (3,3)   {$\mathrm{Gal}(M)$};
\end{tikzpicture}
```

Step 1: Aligning the Nodes

Basic Idea.

The Problem

Providing “hard-wired” coordinates like `(3,1.5)` is problematic:

- When you read the code, it is hard to tell, where something will go.
- When you change something later, you may need to change many such coordinates.
- It is hard to make sure that all spacings and alignments are correct.

Possible Solutions

- You can use options like `right=of Delta` to place a node relative to some other node.
- You can use a Ti*k*Z-matrix. It works like a LaTeX matrix, only inside a picture.

Step 1: Aligning the Nodes.

Alignment Using a Matrix.

	$\mathrm{Gal}(M)$
Δ	$\mathrm{Gal}(\hat{N}/M)$
(E/E')	

```
\matrix[column sep=1cm,row sep=1cm]
{
                           & \node (GalM)  {$\Gal(M)$};        \\
  \node (Delta) {$\Delta$};& \node (GalNM) {$\Gal(\hat N/M)$};\\
  \node (EE)    {$(E/E')$};&                                   \\
};
```

Step 1: Aligning the Nodes.

Simplified Version...

$$\mathrm{Gal}(M)$$

$$\Delta \qquad \mathrm{Gal}(\hat N/M)$$

$$(E/E')$$

```
\matrix [column sep=1cm,row sep=1cm,matrix of math nodes] (fig)
{
         & \mathrm{Gal}(M)        \\
  \Delta & \mathrm{Gal}(\hat N/M) \\
  (E/E') &                        \\
};
% Reference Gal(M) as (fig-1-2)
```

Step 1: Aligning the Nodes.

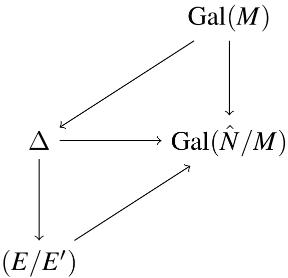
...With Alternate Naming of Nodes.

$$\begin{matrix} & \mathrm{Gal}(M) \\ \Delta & \mathrm{Gal}(\hat{N}/M) \\ (E/E') & \end{matrix}$$

```
\matrix [column sep=1cm,row sep=1cm,matrix of math nodes]
{
                   & |(M)|  \mathrm{Gal}(M)        \\
  |(Delta)| \Delta & |(NM)| \mathrm{Gal}(\hat N/M) \\
  |(EE)|    (E/E') &                               \\
};
% Reference Gal(M) as (M)
```

Step 2: Connecting the Nodes.

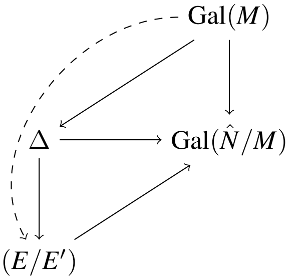
Simple Straight Line.




```
\matrix [column sep=1cm,row sep=1cm,matrix of math nodes]
{
                      & |(M)|  \Gal(M)         \\
  |(Delta)| \Delta & |(NM)| \Gal(\hat N/M) \\
  |(EE)|    (E/E') &                          \\
};
\draw (M)      edge [->] (Delta)
               edge [->] (NM)
      (Delta)  edge [->] (NM)
               edge [->] (EE)
      (EE)     edge [->] (NM);
```

Step 2: Connecting the Nodes.

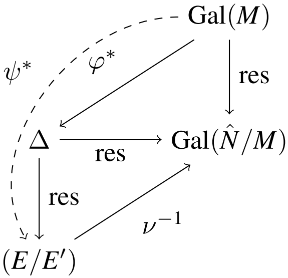
The Curved, Dashed Line.




```
\draw (M)      edge [->] (Delta)
               edge [->] (NM)
               edge [->,dashed,out=180,in=120] (EE)
      (Delta) edge [->] (NM)
               edge [->] (EE)
      (EE)     edge [->] (NM);
```

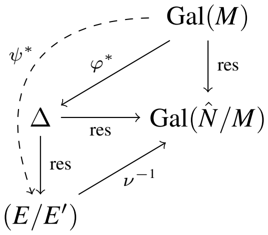
Step 2: Connecting the Nodes.

Adding the Labels




```
\draw [auto=right]
  (M)     edge [->] node {$\varphi^*$}        (Delta)
          edge [->] node [swap] {res}         (NM)
          edge [->,dashed,out=180,in=120]
                    node {$\psi^*$}           (EE)
  (Delta) edge [->] node {res}                (NM)
          edge [->] node [swap] {res}         (EE)
  (EE)    edge [->] node {$\nu^{-1}$}         (NM);
```

Step 3: Finishing Touches

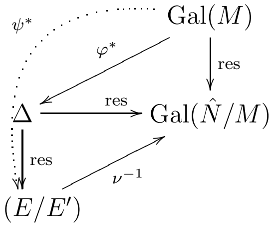


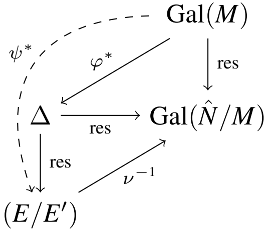
- Adjust "looseness" of the curve and dash phase.
- Reduce distance of φ^*, ψ^* and ν^{-1} to the line.
- Make edge labels smaller (as in $A \xrightarrow{X} B$)

THE COMPLETE CODE.

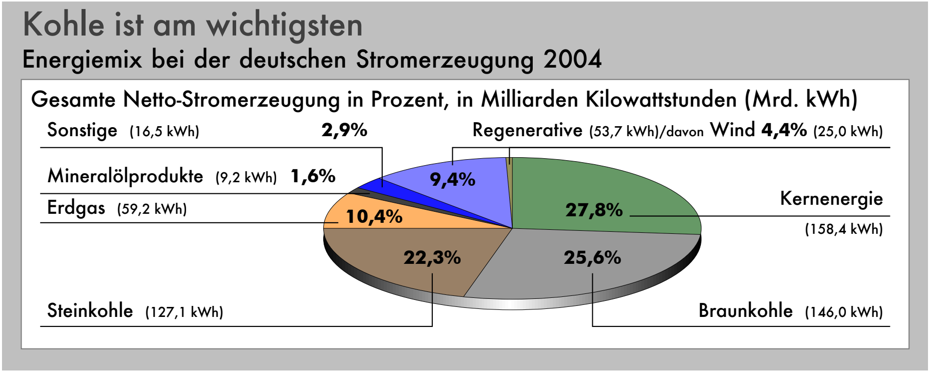
```
\begin{tikzpicture}
  \matrix [column sep=7mm,row sep=7mmm,matrix of math nodes]
  {
                      & |(M)|  \Gal(M)        \\
    |(Delta)| \Delta  & |(NM)| \Gal(\hat N/M) \\
    |(EE)|    (E/E')  &                       \\
  };
  \draw [auto=right,nodes={font=\scriptsize}]
    (M)     edge [->] node [inner sep=0pt] {$\varphi^*$} (Delta)
            edge [->] node [swap]          {res}         (NM)
            edge [->,out=180,in=110,looseness=1.4,
                  dashed,dash phase=3pt]
                      node [inner sep=0pt] {$\psi^*$}    (EE)
    (Delta) edge [->] node                 {res}         (NM)
            edge [->] node [swap]          {res}         (EE)
    (EE)    edge [->] node [inner sep=0pt] {$\nu^{-1}$}  (NM);
\end{tikzpicture}
```

Comparison of Original and Reworked Figure.



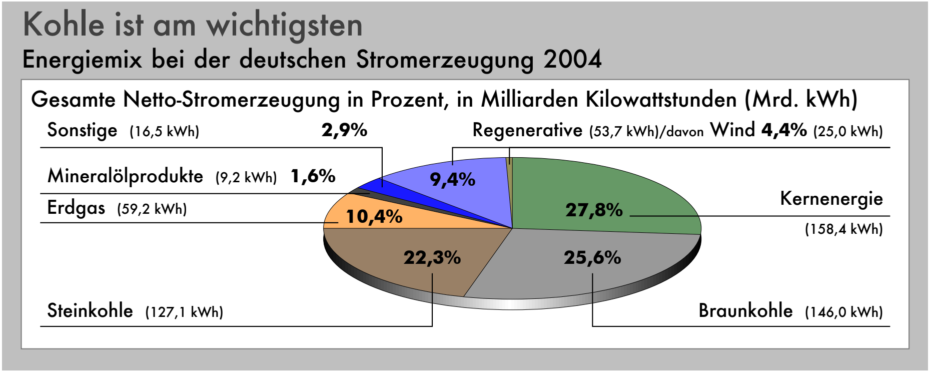


A Figure From a Major German Newspaper.



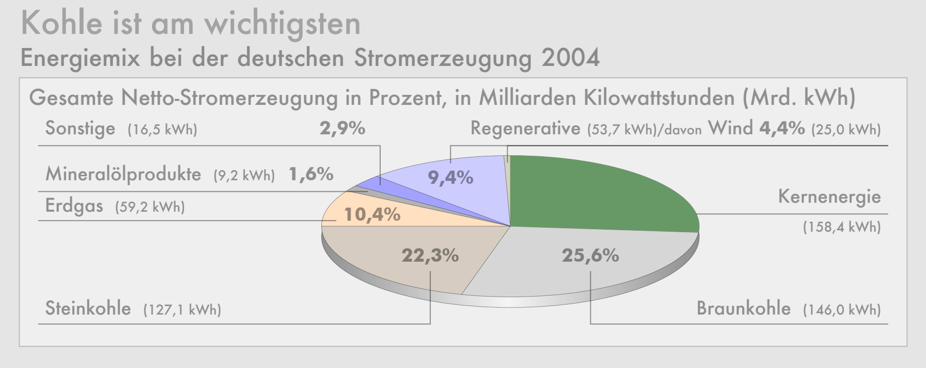
This figure is a redrawing of a figure from “Die Zeit,” June 4th, 2005.

Critique.



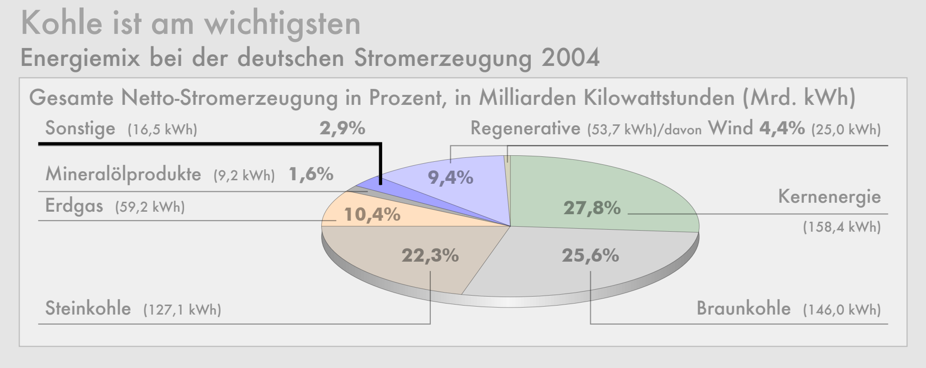
- Coloring is random and misleading.
- Pie slice sizes do not reflect percentages.
- Main message is lost since coal is split across page.

Detail 1: Pie Slices are Elliptic Arcs.



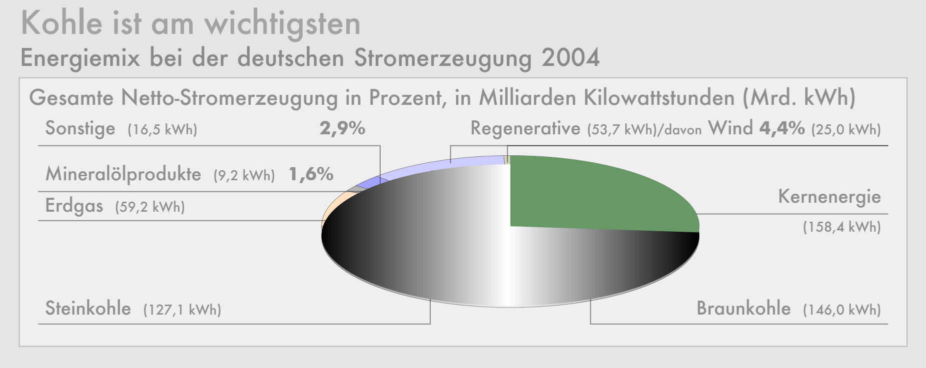

```
\fill[green!20!gray]
     (0,0)
  -- (90:1.2cm)
  arc[start angle=90, end angle=-5,
      x radius=3.2cm, y radius=1.2cm]
  -- cycle;
```

Detail 2: A Horizontal/Vertical Junction.



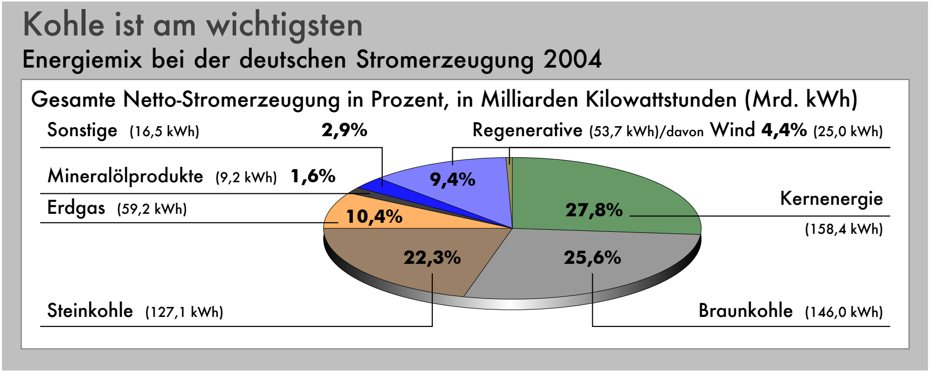

```
\draw[very thick] (-22mm,7mm) |- (-80mm,14mm);
```

Detail 3: The Shading in the Pie Chart.



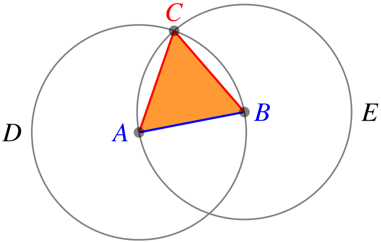

```
\shade [left color=black,right color=black,middle color=white]
  (0mm,-1.5mm) ellipse [x radius=3.2cm, y radius=1.2cm];

\fill[green!20!gray]
      (0,0)
  -- (90:1.2cm)
  arc[start angle=90, end angle=-5,
      x radius=3.2cm, y radius=1.2cm]
  -- cycle;
```

The Complete Figure.



The complete figure can be constructed in this way.

A Geometrical Construction



Euclid of Alexandria

Proof of Proposition I

Elements, Book I

Step 1: The Line AB

A Simple Line

```
\begin{tikzpicture}
  \coordinate (A) at (0,0);
  \coordinate (B) at (1.25,0.25);

  \draw[blue] (A) -- (B);
\end{tikzpicture}
```

- The `\coordinate` command is a shorthand for the `\node` command with empty text.

Step 1: The Line AB

Adding Labels


```
\begin{tikzpicture}
  \coordinate [label=left:\textcolor{blue}{$A$}]
    (A) at (0,0);

  \coordinate [label=right:\textcolor{blue}{$B$}]
    (B) at (1.25,0.25);

  \draw[blue] (A) -- (B);
\end{tikzpicture}
```

- The `label` option makes it easy to add some text around another node.
- Alternatively, one could explicitly create a node later on.

Step 1: The Line *AB*

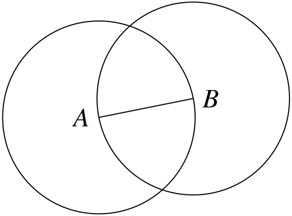
Perturbed Positions


```
\usetikzlibrary{calc}
\begin{tikzpicture}
  \coordinate [label=left:\textcolor{blue}{$A$}]
    (A) at ($ (0,0) + .1*(rand,rand) $);

  \coordinate [label=right:\textcolor{blue}{$B$}]
    (B) at ($ (1.25,0.25) + .1*(rand,rand) $);

  \draw[blue] (A) -- (B);
\end{tikzpicture}
```

- Between `($` and `$)` you can do some basic linear algebra on coordinates.

Step 2: The Circles

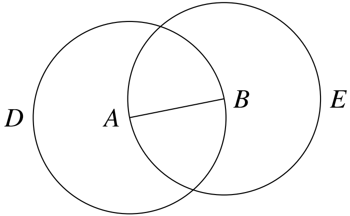
Using the Let Operation




```
...
\draw (A) -- (B);

\draw let
        \p1         = ($ (B) - (A) $)
      in
        (A) circle [radius={sqrt(\x1*\x1+\y1*\y1)}]
        (B) circle [radius={sqrt(\x1*\x1+\y1*\y1)}];
```

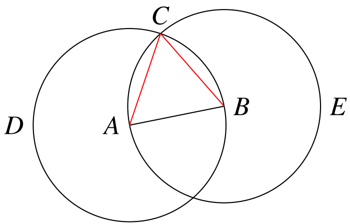
Step 2: The Circles

Using the Through Library



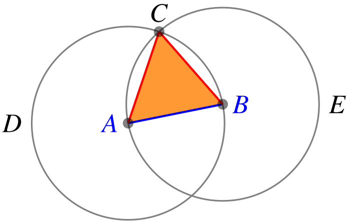

```
\usetikzlibrary{through}
...
\draw (A) -- (B);

\node at (A) [draw,circle through=(B),label=left:$D$]  {};
\node at (B) [draw,circle through=(A),label=right:$E$] {};
```

Step 3: The Intersection of the Circles




```
\usetikzlibrary{intersections}
...
\draw (A) -- (B);
\node at (A) [name path=D,draw,circle through=(B),label=...] {};
\node at (B) [name path=E,draw,circle through=(A),label=...] {};

\node [name intersections={of=D and E, by=C}]
   at (C) [above] {$C$};

\draw [red] (A) -- (C)   (B) -- (C);
```

Step 4: Finishing Touches



- Add transparent circles at the points A, B, and C.
- Fill triangle, but on the background layer.

The Complete Code

```
\begin{tikzpicture}[thick,
                    help lines/.style={semithick,draw=black!50}]
  \coordinate [label=left:\textcolor{blue}{$A$}]
    (A) at ($ (0,0) + .1*(rand,rand) $);
  \coordinate [label=right:\textcolor{blue}{$B$}]
    (B) at ($ (1.25,0.25) + .1*(rand,rand) $);
  \draw [blue] (A) -- (B);

  \node at (A) [circle through=(B),name path=D,
                help lines,draw,label=left:$D$] {};
  \node at (B) [circle through=(A),name path=E,
                help lines,draw,label=right:$E$] {};

  \node [name intersections={of=D and E, by=C}]
     at (C) [above] {$C$};
  \draw [red] (A) -- (C)   (B) -- (C);

  \foreach \point in {A,B,C}
    \fill [black,opacity=.5] (\point) circle (2pt);

  \begin{pgfonlayer}{background}
    \fill[orange!80] (A) -- (C) -- (B) -- cycle;
  \end{pgfonlayer}
\end{tikzpicture}
```