

Some tips on making posters with Latex

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Abstract

This document contains sample code from a poster I presented at the European Conference of Mathematical and Theoretical Biology in 2005. The intention is to highlight some of the things that can be done with \LaTeX for the production of conference posters.

1 Preamble

As with all \LaTeX files, the preamble containing details of the extra packages used is required. Here is the preamble for `poster1.tex`:

```
\documentclass[a0,portrait]{a0poster}
```

I forget whether `a0poster.cls` is part of the standard \LaTeX installation or not. You should probably look for it anyway as the users manual is excellent and, furthermore, you tend to find it on webpages with other resources for creating posters with \LaTeX .

```
\RequirePackage{amssymb,amsthm,array}
\RequirePackage[reqno]{amsmath}
```

Standard packages used in everyday \LaTeX concerning the look and feel of theorem environments, arrays and mathematical symbols. Don't forget these, especially if the first draft of your poster is just the act of cutting and pasting existing work in to a poster file before starting to position and edit the content.

```
\usepackage{pstcol}
\usepackage[final]{graphicx}
\usepackage{alltt,a4,float,verbatim,cite,calc,multicol,wrapfig}
\usepackage[absolute]{textpos}
\usepackage[it]{subfigure}
\usepackage{boxedminipage}
```

These are the extra packages you might require. I will describe the more important ones below. Most are present within a standard \LaTeX installation and the rest are very easy to find on the internet. Just google the package name and perhaps add the word latex. The internet will also provide far better instructions on the use of these packages than I ever could. You should certainly have a peek at this information because using extra options could make your posters even better!

```
\renewcommand\familydefault{cmss}
```

This command changes the whole document into a sans serif font. There is some debate about whether text is easier to read in a sans serif or serif font. I opted for san serif because I didn't want something too formal.

```
\newcommand\Xlft{5mm} \newcommand\Xrt{836mm}
\newcommand\Ytop{5mm} \newcommand\Ybtm{1164mm}
\newcommand\PaneW{390mm}
```

These are commands that supply lengths that are used over and over and over again. You may find yourself changing them a lot, so it is useful to do this.

```
\newcommand{\PP}{\mathbb{P}}
```

This just renders a P in the mathbb font style. I do this for all double face letters in my documents.

```
\newcommand{\map}{\includegraphics [width=100mm] {/home/mapmdd/eps/map.eps}}
\newcommand{\pica}{\includegraphics [width=11cm] {/home/mapmdd/eps/twelve13.eps}}
\newcommand{\picb}{\includegraphics [width=11cm] {/home/mapmdd/eps/poster5.eps}}
\newcommand{\picc}{\includegraphics [width=11cm] {/home/mapmdd/eps/poster2.eps}}
```

If you are going to experiment with the positioning of various graphic elements, it is helpful to set up some shorter commands that will place graphics without obscuring the rest of your code. As with the lengths, it is also good to do this when you have elements that appear more than once. An example would be if you have boxes with the same background.

```
\newenvironment{altDescription}[1]
{\begin{list}{}%
{\renewcommand\makelabel [1]{\textsf{\textbf{##1}}\hfil}%
\settowidth\labelwidth{\makelabel{#1}}%
\setlength\leftmargin{\labelwidth+\labelsep}}%
{\end{list}}
```

This sets up a new environment called `altDescription` which formats a list of definitions slightly differently to the default. Sometimes you'll have to resort to this in the production of posters because what works in reports and papers, sometimes does not quite translate. On the poster that this code produces, the first appearance is in a list of network terminology in the top pane on the left hand side. The enviroment styles lists so that the labels you give to items are all the same width as the widest one. On my poster this means that all the labels on that list of network terminology are the same width as the phrase *degree distribution*. The default behaviour of `itemize` and its cousins is a little strange, especially in a poster context. Here is an example of how it might be used:

```
\begin{altDescription}{longest tag}
\item[longest tag] This is the thing to be defined with the longest name.
\item[shorter] This is the definition of something with a shorter name.
```

```

\item[tiny] Size isn't everything they say.
\item[you will get into trouble] If you're not careful.
\end{altDescription}
% NB Note the deliberate mistake!
% Just to point out this out as the error messages can be cryptic.

```

2 Useful packages

2.1 pstcol

This is the PS Tricks package which provides all kinds of bells and whistles for producing vector graphics within a \LaTeX setting. It's only used here for the coloured borders and regions. If you're not so keen on demarcating regions graphically, then maybe you don't need to use it. A word of warning to Mac users though, this package requires the use of the `dvips` command which is bypassed in the \LaTeX compilation procedures of many Mac installations. Likewise, if you usually use the more direct `pdflatex` route you will also have problems. For both sets of users there is an alternative in the form of the imaginatively named PDF Tricks but I have not had the opportunity to use it yet. If I get the chance, I will add a section on this later.

Most of the commands beginning `\ps` in the sample code below are provided by PS Tricks. However, I am not going to go into detail because there are so many such commands available that it would probably be more beneficial to point you towards the manual. This can be found at

<http://www.tex.uniya.ru/doc/pst.ug.pdf>

The `col` component of the name is a reference to a version with more colouring options. If you are not too fussed about colours, try `pst`.

2.2 graphicx

You'll probably have encountered this one before. This allows for the use of graphics with the `\includegraphics` command. When I produced the poster that this sample code generates, all the files had to be in `eps` format but now I am not so sure. These days I merrily include graphics files with nary a thought for their format but this may just be a Mac thing.

2.3 calc

For producing a poster, this package is crucial. It adds a functionality to \LaTeX that you might expect to be a default - the ability to provide arguments to environments based on arithmetic expressions. When you are working with lengths this is a godsend. For example, if I have set lengths for the left margin, the width of the left pane and the separation between panes as `\LeftMargin`, `\LeftPaneWidth` and `\PaneSep` respectively; then I could draw my text block (see below) with the following command:

```

% Text block to the right of another, at the top of the poster
% >> denotes an inserted line break
\begin{textblock*}{\RightPaneWidth}{\LeftMargin+\LeftPaneWidth+\PaneSep,>>
\TopMargin+\HeaderHeight+2*\HeightSep}
...
\end{textblock*}

```

The best thing being that if I change one of the predefined measurements, everything built upon it will change. This is because the textblocks can be positioned absolutely. This is extremely useful, provided you take control of the situation from the outset.

2.4 multicol

This is another general package which often gets used with `beamer`. You can use it in the following way to produce columns of text:

```

\begin{multicols}{N}
% N is the number of columns, obviously
\end{multicols}

```

2.5 wrapfig

I will be honest and say that either I was not able to get this to work or I decided that the results did not look good enough to use. As a package, `wrapfig` is concerned with flowing text around an image. You can find out more in the `LATEX` companion or via google.

2.6 textpos

Along with `calc` this is the most useful package. It has been designed with the production of large format posters in mind. You can find a wealth of information about both the package and producing conference posters with `LATEX` on the following website:

<http://nxg.me.uk/dist/textpos/>

The example given for `calc` shows how the textblock regions for `textpos` are created. Finally, to put text inside these regions you will need...

2.7 boxedminipage

This package produces regions of text of a particular width.

3 Boxes, boxes everywhere!

If you imagine how you would use powerpoint create a coloured box containing text, it would probably go as follows:

- Click your mouse on the page where you want the top left corner of the rectangle to be.
- Draw out your rectangle out across where you want it to be, having defined the colour and the border style etc etc.
- Click again inside your new (coloured box) and start typing.

The L^AT_EX equivalent we have been describing is as simple of this, it just involves more imagination and less mouse work. Which packages do each of the jobs? Well, it roughly follows the following schematic:

- `textpos`
- `pstcol` (Though some aspects like the width will have been taken care of by `textpos`)
- `boxedminipage` (Perhaps more equivalent to something like Photoshop or Paint where you have to explicitly select a text tool in order to type)

Do not forget that you will have to supply a width for the minipage that you insert the text into. Although this may seem like an inconvenience, this can allow for some clever tricks using other minipages within arrays. Examples include the management of boxes where you want to put a picture to one side of some text without using/needs a package like `wrapfig` (see above). As an example of this three box technique and also the “text box next to a picture technique”, let us have a look at the top right text pane of the Dresden poster:

```
\begin{textblock*}{\PaneW+15mm}(\paperwidth-30mm-\PaneW, \Ytop+60mm)
\psset{fillcolor=white, linecolor=bathuni, linewidth=2mm}
\psframebox[framearc=.05, framesep=4mm]{%
\begin{minipage}[t]{\PaneW}
\begin{tabular}{@{}lc@{}}
\begin{minipage}[c]{285mm}
\bathuni{\textsf{\textbf{Bristol}} is a vibrant city in the south west
of the United Kingdom with a growing population currently standing
at around 400,000 (2001 census) and a diverse demography. The sexual
health facilities of this region also cover Bath and the remainder of
North East Somerset, bringing its total catchment area to potentially
500,000 sexually active individuals.\newline
Bristol is currently experiencing outbreaks of two STIs, Hepatitis B
and Syphilis. It is the only city in Britain to report two
simultaneous episodes of this nature. The Health Trust is also
managing around 400 known cases of HIV and AIDS. A number of highly
active, high risk groups within the population have been identified
```

```

and it would be valuable to model how the structure of contacts
within and between these groups, as well as the population at large,
affects predictions for future STI and HIV incidence.}}
\end{minipage} &
\begin{minipage}[c]{105mm}
\map %Shortcut for \includegraphics command
\end{minipage}
\end{tabular}
\end{minipage}
}
\end{textblock*}

```

4 Other information

4.1 Colours

Colours are defined within the document with either the command `\newrgbcolor` or `\newcmykcolor`, depending on which colour space you are most happy inhabiting. Either command takes the form:

```
\newrgbcolor{User defined colour name}{red_level, green_level, blue_level}
```

The colour levels can either be integers between 0 and 255 or the corresponding proportions between 0 and 1. Hex codes may also be acceptable, I will try and find out. As an example, here is a command that will produce the exact blue so favoured by our beloved University:

```
\newcmykcolor{bathuni}{1 0.7 0 0.15}
```

4.2 Font sizes

This list of font sizes is taken directly from the documentation for `a0poster`:

<code>\tiny</code>	12pt
<code>\scriptsize</code>	14.4pt
<code>\footnotesize</code>	17.28pt
<code>\small</code>	20.74pt
<code>\normalsize</code>	24.88pt
<code>\large</code>	29.86pt
<code>\Large</code>	35.83pt
<code>\LARGE</code>	43pt
<code>\huge</code>	51.6pt
<code>\Huge</code>	61.92pt
<code>\veryHuge</code>	74.3pt
<code>\VeryHuge</code>	89.16pt
<code>\VERYHuge</code>	107pt

A Sample code: poster1.tex

Here is the code. I have indicated where additional line breaks have been inserted. These are to make this document easier to read:

```
% >> denotes an inserted line break.
\documentclass[a0,portrait]{a0poster}

\RequirePackage{amssymb,amsthm,array}
\RequirePackage[reqno]{amsmath}
\usepackage{pstcol}
\usepackage[final]{graphicx}
\usepackage{alltt,a4,float,verbatim,cite,calc,multicol,wrapfig}
\usepackage[absolute]{textpos}
\usepackage[it]{subfigure}
\usepackage{boxedminipage}

\renewcommand\familydefault{cmss}

\newcommand\Xlft{5mm} \newcommand\Xrt{836mm}
\newcommand\Ytop{5mm} \newcommand\Ybtm{1164mm}
\newcommand\PaneW{390mm}
\newcommand{\PP}{\mathbb{P}}
\newcommand{\map}{\includegraphics[width=100mm]{/home/mapmdd/eps/map.eps}}
\newcommand{\pica}{\includegraphics[width=11cm]{/home/mapmdd/eps/twelve13.eps}}
\newcommand{\picb}{\includegraphics[width=11cm]{/home/mapmdd/eps/poster5.eps}}
\newcommand{\picc}{\includegraphics[width=11cm]{/home/mapmdd/eps/poster2.eps}}
\pagestyle{empty}

\newenvironment{altDescription}[1]
{\begin{list}{}%
{\renewcommand\makelabel[1]{\textsf{\textbf{##1}}\hfil}%
\settowidth\labelwidth{\makelabel{#1}}%
\setlength\leftmargin{\labelwidth+\labelsep}}}%
{\end{list}}

\begin{document}

\newrgbcolor{brightblue}{0.310 0.749 1}
\newrgbcolor{idealblue}{0.275 0.467 0.757}
\newrgbcolor{nicepink}{0.769 0.369 0.498}
\newrgbcolor{lilac}{0.71 0.62 0.98}
\newrgbcolor{goodgrey}{0.369 0.365 0.341}
\newrgbcolor{brown}{0.678 0.345 0.224}
\newrgbcolor{gentleyellow}{0.998 0.906 0.412}
\newrgbcolor{limegreen}{0.49 0.702 0.118}
\newrgbcolor{lemonyellow}{1 1 0.698}
```

```

\newcmykcolor{bathuni}{1 0.7 0 0.15}
\newrgbcolor{bathuniblue}{0 0.255 0.851}

\begin{textblock*}{790mm}(\Xlft, \Ytop)
\psset{fillcolor=bathuni, linecolor=black}
\psframebox*[framearc=.05, framesep=10pt]{%
\begin{tabular}{l}
\white{\textsf{\VERYHuge{The spread of disease on social
networks\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ }}}>>
\\*[8mm]\white{\textsf{\Large{Matthew Dorey, Department of
Mathematical Sciences, University of Bath, Bath, UK}}}}
\end{tabular}
}
\end{textblock*}

\begin{textblock*}{65mm}(765mm, 5mm)
\psset{fillcolor=white}
\psframebox*[framearc=.05]{%
\includegraphics[height=50mm]{/home/mapmdd/eps/pq1.eps}
}
\end{textblock*}

\begin{textblock*}{65mm}(748mm, 1150mm)
\psset{fillcolor=bathuni}
\psframebox*[framearc=.05]{%
\includegraphics[height=25mm]{/home/mapmdd/eps/logos/bathlogoblue.eps}
}
\end{textblock*}

\begin{textblock*}{65mm}(\paperwidth-30mm-\PaneW, 1150mm)
\psset{fillcolor=white}
\psframebox*[framearc=.05]{%
\includegraphics[height=25mm]{/home/mapmdd/eps/logos/epsrchi2.eps}
}
\end{textblock*}

\begin{textblock*}{\PaneW}(\Xlft, \Ytop+60mm)
\psset{fillcolor=white, linecolor=bathuni, linewidth=2mm}
\psframebox[framearc=.05, framesep=4mm]{%
\begin{minipage}[t]{\PaneW-10mm}
\large{\textsf{\bathuni{Sexually transmitted infections (STIs) are
infections whose primary route of transmission is through sexual
contact. Examples include Chlamydia, Syphilis and Hepatitis B.}}}}
\textsf{\bathuni{\normalsize{
\columnsep=10mm
\begin{multicols}{2}
Features of sexually transmitted infections:

```



```

\begin{flushright}
\begin{itemize}
\item Increasingly common.
\item Often asymptomatic, with long recovery times. Those infected
with Hepatitis B become carriers.
\item Serious health complications later on (infertility, liver
disease, cancer etc) if asymptomatic diseases go undiagnosed or
untreated.
\item Whilst the initial infections are often simple to treat,
sequelae can require complex and expensive treatment.
\item Symptoms often increase production of HIV susceptible
cells in hosts, leading to a synergy between HIV and STIs.
\end{itemize}
\end{flushright}

```

Sociological contributions to increased STI incidence:

```

\begin{flushright}
\begin{itemize}
\item Average number of lifetime partners per individual has
increased
\item More mobile populations introduce new strains of existing
diseases (migration, sex tourism etc).
\item Better detection rates.
\item Age at first intercourse decreasing.
\item Higher incidence of partnership concurrency.
\item Discussion of STIs is still taboo in many cultures.
\item Inadequate education and access to sexual health facilities.
\end{itemize}
\end{flushright}
\end{multicols}
}}

```

Unlike many infectious diseases, STIs require consideration of the underlying contact structure, due to varying levels of sexual activity within the population. Several studies [cite{LiljerosEtAl03}](#) have shown that the distribution of number of partners follows a power law. Recent work in ‘‘complex networks’’ [cite{Newman03}](#) has found that networks with power law degree distributions have very interesting properties. Below we describe some qualitative features of networks in terms of modelling the spread of STIs}}

\normalsize{\textsf{\bathuni{

\begin{flushright}

\begin{altDescription}{degree distribution}

\item[node] Nodes represent individuals within the population

\item[edge] Edges represent (potential) sexual contacts between individuals

\item[degree] The number of partners of an individual

\item[degree distribution] The proportion $\mathbb{P}(k)$ of nodes that are of degree k is known as the degree distribution.>>

```

\\A \textsf{\textbf{scale-free}}
network has degree distribution  $P(k) \sim k^{-\gamma}$ , >>
with  $\gamma \in (2,3)$ 
\item[clustering] This gives a measure of likely it is that your
neighbour's neighbour is also your neighbour. It is often averaged
over all nodes. It is usually defined in terms of triangles in the
network and so has to be redefined in the context of a heterosexual
contact structure, where triangles will not exist.
\item[degree correlation] This distribution gives us the likelihood
that a node of degree  $m$  is connected to one of degree  $n$ . The
cases  $m$  high,  $n$  high, and  $m$  high,  $n$  low, are known as
assortative and disassortative correlation respectively.
\item[path length] What distance is a given individual from the rest
of the population?
\item[centrality scores] There are numerous methods of ranking
individuals according to how crucial they are to the network as a
whole. We use the \textsf{\textbf{information centrality}} as defined
in \cite{WassermanFaust94}.
\end{altDescription}
\end{flushright}
}}
\large{\textsf{\bathuni{The aim of our research is to discern the
effects of these network properties (and others) on the spread of
disease, particularly in the context of human sexual contact
networks and sexually transmitted infections. We are interested in
using real data (see top right) to motivate simulations of disease on
various network structures (below) and in developing mathematical
models to help validate these simulations and provide further insight
into the real world data.}}}
\end{minipage}
}
\end{textblock*}

```

```

\begin{textblock*}{\PaneW+15mm}{\paperwidth-30mm-\PaneW, \Ytop+60mm}
\psset{fillcolor=white, linecolor=bathuni, linewidth=2mm}
\psframebox[framearc=.05, framesep=4mm]{%
\begin{minipage}[t]{\PaneW}
\begin{tabular}{@{}lc@{}}
\begin{minipage}[c]{285mm}
\bathuni{\textsf{\textbf{Bristol}} is a vibrant city in the south west
of the United Kingdom with a growing population currently standing
at around 400,000 (2001 census) and a diverse demography. The sexual
health facilities of this region also cover Bath and the remainder of
North East Somerset, bringing its total catchment area to potentially
500,000 sexually active individuals.\newline
Bristol is currently experiencing outbreaks of two STIs, Hepatitis B
and Syphilis. It is the only city in Britain to report two

```

simultaneous episodes of this nature. The Health Trust is also managing around 400 known cases of HIV and AIDS. A number of highly active, high risk groups within the population have been identified and it would be valuable to model how the structure of contacts within and between these groups, as well as the population at large, affects predictions for future STI and HIV incidence.}}

\end{minipage} &

\begin{minipage}[c]{105mm}

\map

\end{minipage}

\end{tabular}

\end{minipage}

}

\end{textblock*}

\begin{textblock*}{\PaneW+15mm}(\paperwidth-30mm-\PaneW, \Ytop+200mm)

\psset{fillcolor=bathuni}

\psframebox*[framearc=.05, framesep=10.7pt]{%

\begin{minipage}[t]{\PaneW+5mm}

\white{\textsf{

For a mathematical description of the spread of disease, we have followed the pair-wise model of Eames and Keeling \cite{EamesKeeling02} which considers degree-degree correlations within the contact network.

\small{

\begin{flushright}

\begin{altDescription}{Refining approximation\ }

\item[Notation] We follow their notation of labeling susceptibles and infectives S and I respectively. S^n is then the number of susceptibles of degree n and $S^n I^m$ is the number of susceptibles of degree n that are connected to an infective of degree m . The triple $A^m B^n C^p$ represents the number of individuals of degree m in state B connected to nodes of degree n and p that are in states A and C respectively. As in the simulations α is the rate at which infection is spread through a contact and γ is the recovery rate.

\item[Individual events] Either an infected individual recovers or makes contact with its neighbours as described by the equation:

\begin{equation}

$$\frac{d[I^n]}{dt} = -\gamma[I^n] + \alpha \sum_m [S^n I^m]$$

\end{equation}

\item[Dynamics of pairs] Considering $S^n I^m$ we have the equation

\begin{equation}\label{SI}

$$\frac{d[S^n I^m]}{dt} = \alpha \sum_p ([S^n S^m I^p] - [I^p S^n I^m]) - \alpha [S^n I^m] + \gamma ([I^n I^m] - [S^n I^m])$$

\end{equation}

We lose these pairs if the susceptible half is infected or the infective half recovers. These increase if the right half of an

$S^n S^m$ pair is infected or if the left half of an $I^n I^m$ pair recovers. Infection can occur from outside of pairs, so these equations also include triples.

Triple approximation To close the system, the number of triples is approximated in terms of pairs using the following formula:

$$[A^n B^m C^p] \approx \frac{(m-1) [A^n B^m] [B^m C^p]}{m [B^m]}$$

The number of triples $[A^n B^m C^p]$ is roughly the number of $[A^n B^m]$ pairs whose remaining $m-1$ links go on to connect to a C^p .

Refining approximation For networks with a large maximum degree, the number of equations required to be solved for the n - m pairs grows quickly. Where possible we sum over m to get, for example the number of susceptibles of degree n connected to an infective, denoted $[S^n I] = \sum_m [S^n I^m]$. In some places it is impossible to naively perform this summation and instead we use:

$$[A^n B^m] \approx \frac{[A^n B] [B^m A]}{[AB]} \times \underbrace{\frac{[nm]}{\sum_{q,q'} [n]_m [m]_{q'}}}_{:= \kappa_{nm}}$$

The first term describes the likelihood of finding an A^n next to a B and a B^m next to an A , while the second term handles the degree correlations - the chance of finding an n - m pair.

Final equations After writing down equations similar to (\ref{SI}) for $d[S^n S^m]/dt$, $d[I^n S^m]/dt$ and $d[I^n I^m]/dt$, and applying approximations (\ref{tripapp}, \ref{refapp}) we have:

$$\begin{aligned} \frac{d[S^n]}{dt} &= \gamma [I^n] - \alpha [S^n I] \\ \frac{d[I^n]}{dt} &= \alpha [S^n I] - \gamma [I^n] \\ \frac{d[S^n S]}{dt} &= -\alpha \sum_m \left(\frac{(m-1) [S^m I]}{m [S^m]} \kappa_{nm} \frac{[S^n S] [S^m S]}{\sum_m [S^m S]} \right) - \alpha \frac{[S^n S] [S^n I]}{n [S^n]} + \gamma ([S^n I] + [I^n S]) \\ \frac{d[S^n I]}{dt} &= \alpha \sum_m \left(\frac{(m-1) [S^m I]}{m [S^m]} \kappa_{nm} \frac{[S^n S] [S^m S]}{\sum_m [S^m S]} \right) - \alpha \frac{[S^n S] [S^n I]}{n [S^n]} - \alpha [S^n I] + \gamma ([I^n I] - [S^n I]) \\ \frac{d[I^n S]}{dt} &= -\alpha \sum_m \left(\frac{(m-1) [S^m I]}{m [S^m]} \kappa_{nm} \frac{[I^n S] [S^m I]}{\sum_m [S^m I]} \right) + \alpha \frac{[S^n I]^2}{n [S^n]} - \alpha [I^n S] + \gamma ([I^n I] - [I^n S]) \\ \frac{d[I^n I]}{dt} &= \alpha \sum_m \left(\frac{(m-1) [S^m I]}{m [S^m]} \kappa_{nm} \frac{[I^n S] [S^m I]}{\sum_m [S^m I]} \right) + \alpha \frac{[S^n I]^2}{n [S^n]} + \alpha [I^n S] + \alpha [S^n I] - 2\gamma [I^n I] \end{aligned}$$

Numerical solutions Below we show the numerical solution of the above

equations on a 100 node network. On the left is a Barab\’asi-Albert network with $m=2$ and on the the right is a Watts-Strogatz network with $k=2$ and $p=0.3$.

```
\psframebox*[fillcolor=white]{
\begin{tabular}{@{}cc@{}}
\includegraphics[width=13cm]{/home/mapmdd/eps/poster3.eps}&
\includegraphics[width=13cm]{/home/mapmdd/eps/poster4.eps}
\end{tabular}
}\ \vspace{3mm}
```

For both networks the infection is curtailed by the introduction of the recovery term. The infection seems to follow the same profile as simulations suggest, although the number of infectives at any given time is not as high as simulations would suggest. Also this method does not give us any way of determining when sites are infected for the first time in the way that simulations do.

```
\end{altDescription}
\end{flushright}}}}
\end{minipage}
}
```

```
\begin{textblock*}{\PaneW+15mm}{\Xlft, \Ytop+575mm}
```

```
\psset{fillcolor=bathuni}
\psframebox*[framearc=.05, framesep=4mm]{%
\begin{minipage}[t]{\PaneW-10mm}
```

```
\white{\textsf{We used the following networks for simulation
purposes. A good overview of these and many other network structures
is given in \cite{Newman03}, with the exception of the PQ networks
that were inspired by \cite{Masuda04}, which discusses the
spread of SARS throughout small-world populations.\small{
```

```
\begin{flushright}
```

```
\begin{altDescription}{watts-strogatz\ }
```

```
\item[Scale-free] These networks were developed by Barab\’asi and
Albert and are characterized by a power-law degree distribution. We
build them for simulation by directly employing the preferential
attachment, whereby  $m$  edges for each node are added sequentially
with higher probability to nodes with higher degree. As a model for
the sexual contact network they capture the heterogeneity in activity
levels quite well. The network is dominated by a small number of well
connected ‘hubs’ - known in some STI literature as
‘super-spreaders’. These help produce the characteristic short
average path lengths of these networks.
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\item[Lattice] As a simple comparative test network, we often used a
square lattice where each node is connected to the four points left,
right, above and below it. Whilst the behaviour of a disease process
on this network may not be simpler {em per se}, it is at least
possible to visualise the lattice in a way in which the probabilistic
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networks cannot.

\item[Watts-Strogatz] Duncan Watts and Steven Strogatz introduced their model for a ‘‘small world’’ network as a compromise between the local structure of a lattice and the ‘‘global’’ short paths seen in many social networks. The edges in a ring lattice are rewired to randomly selected nodes with probability p , the intention being to preserve neighbourhoods of lattice structure but also connect distinct lattice segments together with the rewired connections.

\item[PQ] In this model, k components of size c are considered as distinct random graphs with tie probability p . After this, each of the kc nodes is visited in turn and connected to a node in a different component with probability q . There are two interesting extremes on which we simulate. PQ1 denotes a network with high p value and low q value and for PQ2 the roles of p and q are reversed. Thus PQ1 is a series of k tightly knit communities with a few inter-community edges, whereas PQ2 consists of sparse communities and a large number of inter-community links.

\end{altDescription}

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\begin{altDescription}{centre\ }

\item[left] In our first disease process each infective contacts a random neighbour and infects that node with probability α if it is susceptible. Nodes recover with probability one after γ time steps. The dynamics of this process on most networks (see figure, right) show quite a slow permeation of infection to distinct sites with those models that feature high degree nodes not presenting a higher risk of acquiring infection. However, short path lengths (which are also a feature of networks with high degree nodes) play a big role here, with the disease spreading to distinct sites slowest on networks dominated by ‘local’ connections because infected nodes are more likely to be neighbours.

\item[centre] With the presence of high degree nodes in scale-free networks facilitating large numbers of short paths, we began to investigate the effect of choosing the initially infected nodes according to their information centrality score. This scores nodes not just according to degree but also degree correlation in their neighbourhoods, in the sense that a high degree node with low degree neighbours scores less than one with high degree neighbours. We see

that in fact selecting a set of nodes other than the ‘‘best’’ ones seems to lead to a great number of distinct nodes being infected at some point. This is due to an initial quenching of the disease caused by a build up in correlations between infected nodes and the fact that infection can only be passed on to at most one neighbour.

\item[right] For our second disease process, every infective attempts to infect all its susceptible neighbours, each with probability α . Infected nodes then recover with probability γ per time step. Here the dynamics are profoundly affected by the degree distribution of the network, since highly connected nodes can be responsible for a large number of onward infections whilst they are infective. The figure shows that even for extremely low values of α , large numbers of infectives can appear on most topologies that feature short paths.

\end{altDescription}

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\white{\textsf{\small{\textbf{Rewiring networks}}}\The tableau to the right is a caricature of a disease process on a ten node network. Open circles denote infected nodes which contact a neighbour at random and infects them with probability 1 if it is susceptible. Each node recovers after three time steps and rewires the connection to the node that infected it away to another node chosen at random. So far we have yet to obtain consistent results with this approach as the rewiring process tends to turn the network into a random graph. This is the beginning of work that incorporates the effect of disease spread on network structure.}}

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\lathuni{\Large{\textbf{Future Work}}}\small{
\begin{altDescription}{Dynamic networks\ }
\item[Components] The networks we have simulated on up to this point
have always been completely connected. This is not entirely
realistic, see \cite{WylieJolly01} for examples. There are two ways
to achieve this, one is to generate a network that is disconnected to
begin with. The other, as proposed in \cite{EamesKeeling04} is to add
terms that model the formation of active partnerships into the pair
approximation equations.
\item[Multiple diseases] The situation in Bristol requires a
treatment of a simultaneous outbreak of two or more diseases on the
contact network. We feel that pair approximation may no
longer be a viable approach in this case, as it will be difficult to
provide simple closures such as (\ref{tripapp}).
\item[At-risk groups] We wish to create a model that takes into
account the interactions between several high risk groups identified
in Bristol and the remainder of the community.
\item[Dynamic networks] Sexual contact networks are not fixed! By
experimenting with rewiring, we have started to look at the effect of
a chnaging network on the spread of disease and how networks
themselves change as diseases spread.
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\newblock Monogamous networks and the spread of sexually transmitted diseases
\newblock {\em Mathematical Biosciences}, 189:115--130, 2004.
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\bathuni{\small{This work is being supervised by Dr. K.A.J. White >>
and funded by the EPSRC.}}
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plex networks” [1] has found that networks with power law degree distributions have very interesting properties. Below we describe some qualitative features of networks in terms of modelling the spread of STIs

node	Nodes represent individuals within the population
edge	Edges represent (potential) sexual contacts between individuals
degree	The number of partners of an individual
degree distribution	The proportion $\mathbb{P}(k)$ of nodes that are of degree k is known as the degree distribution. A scale-free network has degree distribution $\mathbb{P}(k) \sim k^{-\gamma}$, with $\gamma \in (2, 3)$
clustering	This gives a measure of likely it is that your neighbour's neighbour is also your neighbour. It is often averaged over all nodes. It is usually defined in terms of triangles in the network and so has to be redefined in the context of a heterosexual contact structure, where triangles will not exist.
degree correlation	This distribution gives us the likelihood that a node of degree m is connected to one of degree n . The cases m high, n high, and m high, n low, are known as assortative and disassortative correlation respectively.
path length	What distance is a given individual from the rest of the population?
centrality scores	There are numerous methods of ranking individuals according to how crucial they are to the network as a whole. We use the information centrality as defined in [4].

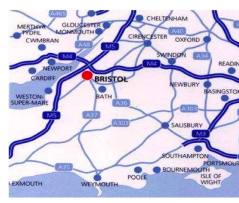
The aim of our research is to discern the effects of these network properties (and others) on the spread of disease, particularly in the context of human sexual contact networks and sexually transmitted infections. We are interested in using real data (see top right) to motivate

Figure 1: Use of the altDescription environment defined in the preamble. For those who attended the away day, notice the typo and one of Petra’s “Garden Path” sentences in the clustering coefficient section!

UK

Bristol is a vibrant city in the south west of the United Kingdom with a growing population currently standing at around 400,000 (2001 census) and a diverse demography. The sexual health facilities of this region also cover Bath and the remainder of North East Somerset, bringing its total catchment area to potentially 500,000 sexually active individuals.

Bristol is currently experiencing outbreaks of two STIs, Hepatitis B and Syphilis. It is the only city in Britain to report two simultaneous episodes of this nature. The Health Trust is also managing around 400 known cases of HIV and AIDS. A number of highly active, high risk groups within the population have been identified and it would be valuable to model how the structure of contacts within and between these groups, as well as the population at large, affects predictions for future STI and HIV incidence.



For a mathematical description of the spread of disease, we have followed the pair-wise model of Eames and Keeling [2] which considers degree-degree correlations within the contact network.

Figure 2: Use of minpages within minipages. This box results from the sample code given in section 3.