WinBUGS Demo

Saghir A. Bashir

With editing by J Cabrera

Outline

- Introduction
- BUGS and WinBUGS
- Graphical Models
- DoodleBUGS
- Example - Simulation
- Power calculation
- Summary

Introduction

- Bayesian Inference Using Gibbs Sampling
  - BUGS
- Analysis of Complex Models
- Bayesian Methods
- Markov Chain Monte Carlo Integration
  - Useful when no closed form exists

Classic BUGS

- Declarative Language
  - Similar to Splus
- Complex Statistical Models
  - Missing data
  - Measurement Error
  - No closed form for Likelihood
- Graphical Modelling
- Flexible compared to approximations

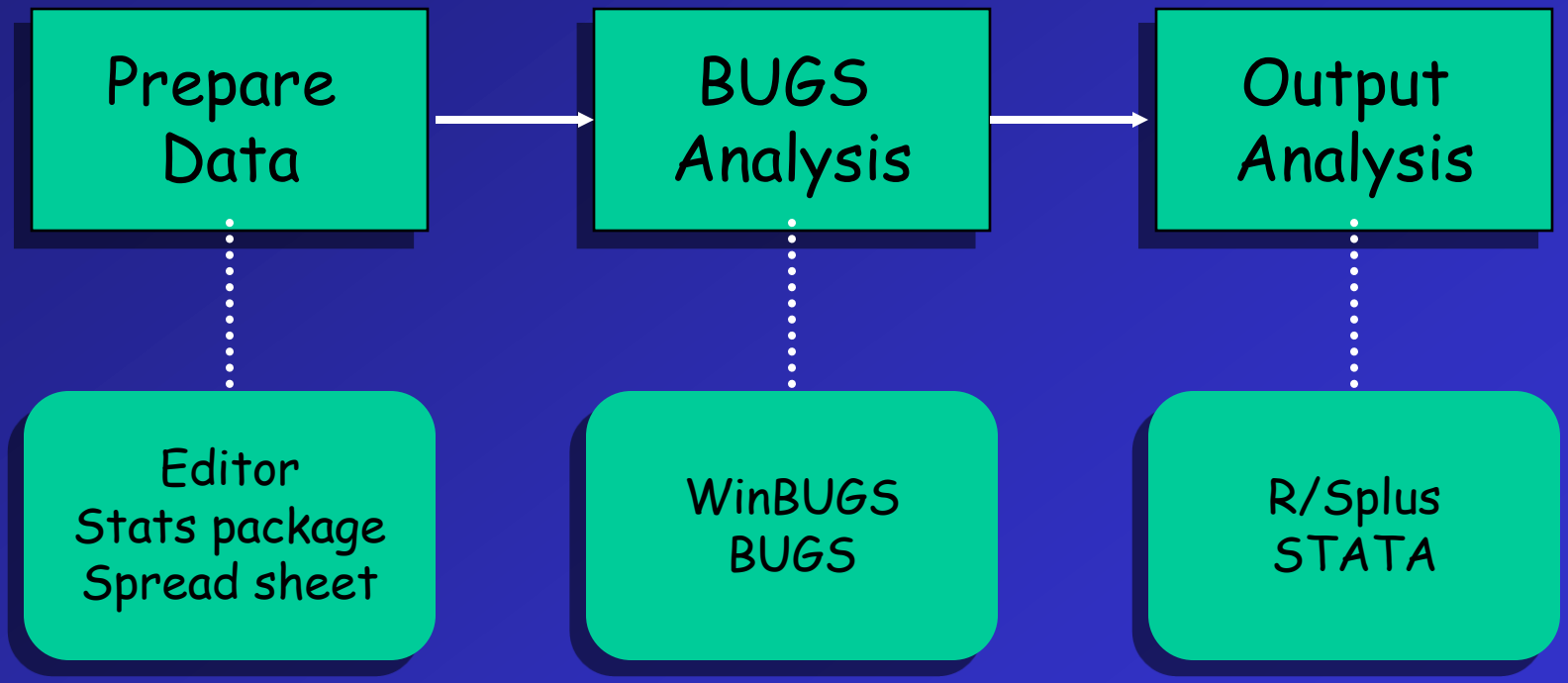
WinBUGS

- Similar to Classic BUGS
  - Plus new methodological developments
- Graphical representation of model
  - DoodleBUGS
- Menu Control of session
- Cut and paste to other packages

BUGS and WinBUGS

- No data management facility
  - Why reinvent the wheel?
- "Easy" interface with other packages
  - R and Splus
  - Stata (S. Bashir)
- Simple analysis of output

Working with BUGS



Graphical Models

- Complex multivariate probability models
  - Representation
  - Visualisation
- Graphs...
  - simplify complex models
  - communicate structure of the problem
  - provide basis for computation

WinBUGS 1.4 BUGS language. DoodleBUGS

To obtain winbugs go to the following website and download the installation file. Make sure that it is installed in C:/ (vista, 7)

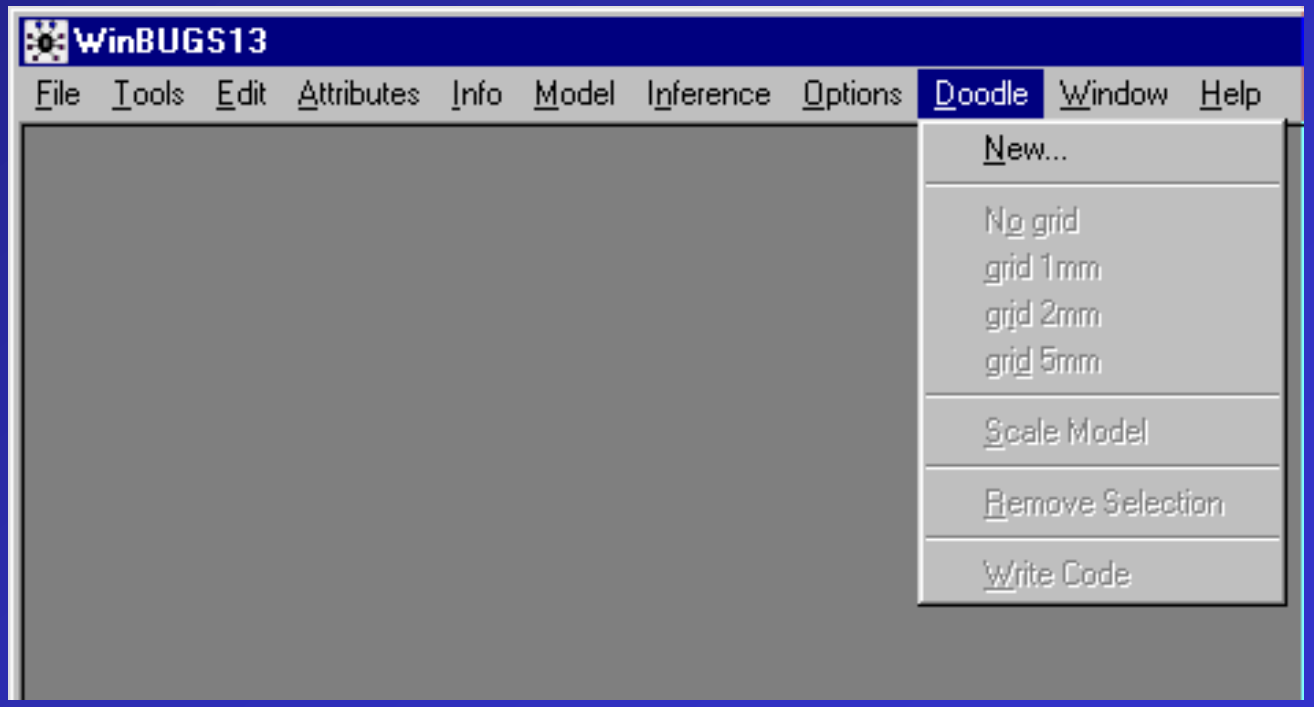
http://www.mrc-bsu.cam.ac.uk/bugs/winbugs/contents.shtml

To install the key for WinBUGS 1.4 please follow these instructions:

1. Start your copy of WinBUGS14.
2. Either a) open this file (menu File option Open) as a .txt file or b) open a new empty window (menu File option New), and cut and copy this email message into the window (WinBUGS will ignore all this preceding text).
3. From the Tools menu pick the Decode option. A dialog box will appear. Click on the "Decode All" button to install the key.
4. Check the date of the file c:\Program Files\WinBUGS14\Bugs\Code\Keys.ocf (or wherever you have installed WinBUGS 1.4). If it shows the current date and time then the upgrade has been successfully installed. Quit and restart WinBUGS to start using the full version.

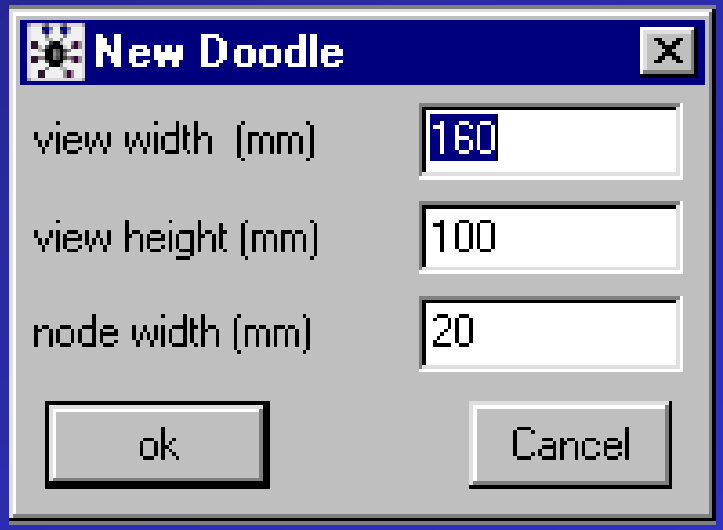
DoodleBUGS

- Start WinBUGS
- Select "Doodle" from menu bar



DoodleBUGS - Basics

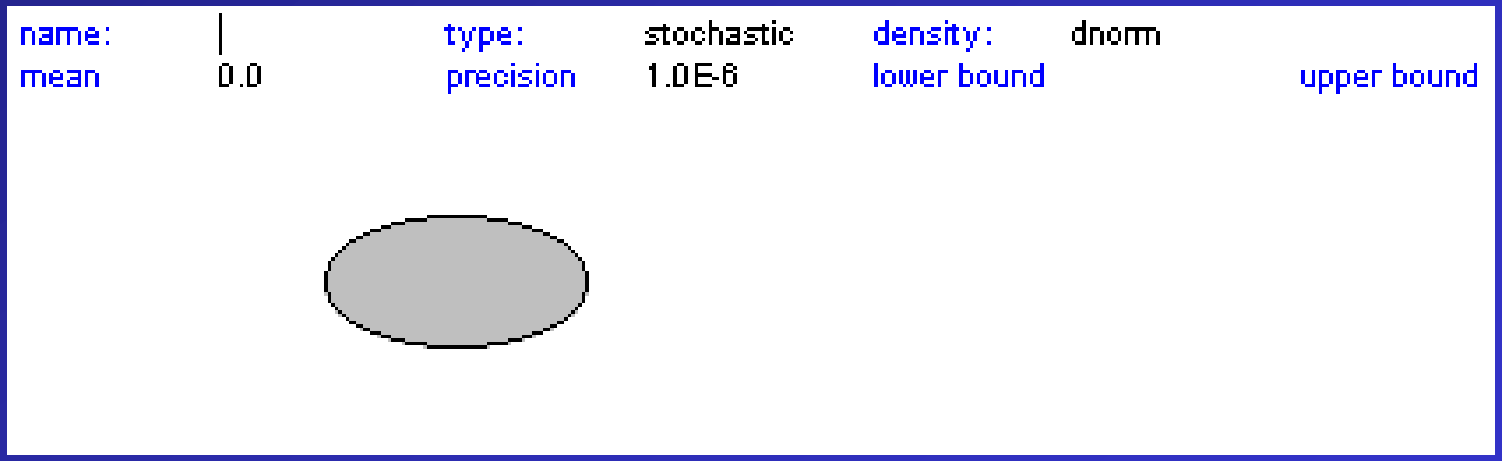
- Select "New..."



- Press "ok"
- You have a window to "Doodle" in.

Nodes

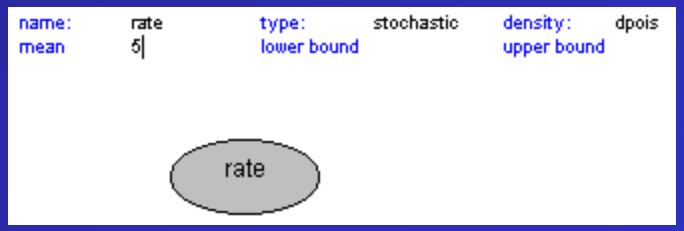
- Creating a node
  - Mouse click in Doodle Window



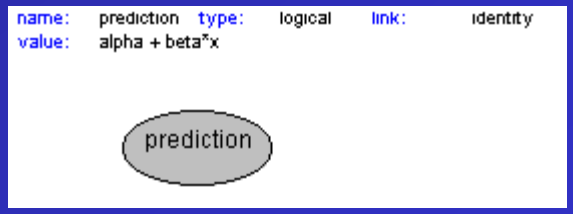
- Deleting a node: CTRL + Del

Node Types

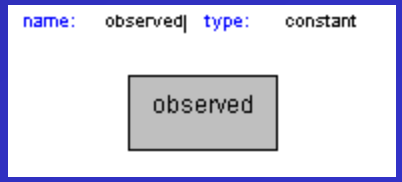
- Nodes can be
  - Stochastic



  - Logical



  - Constant (rectangle)

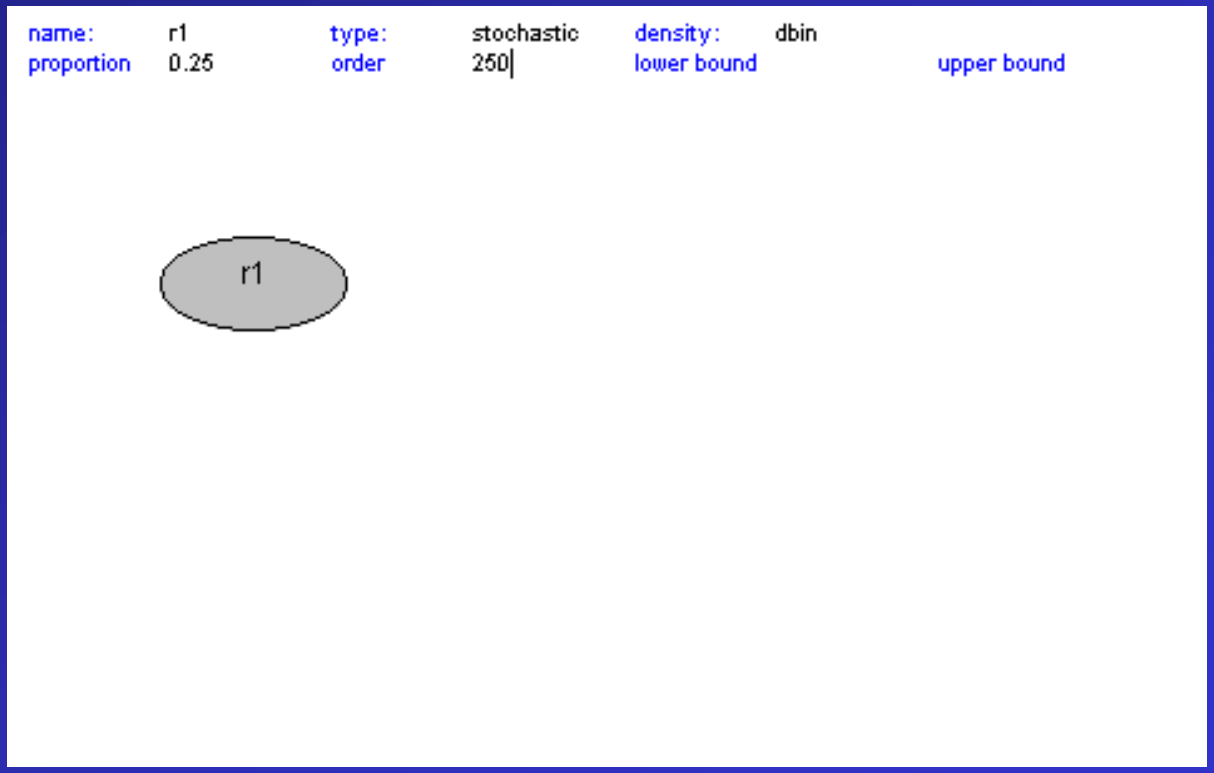


Example - Simulation

- Let
  - r1 ~ Bin (0.25, 250)
  - r2 ~ Bin (0.35, 150)
- Calculate p: common proportion for r1 & r2
- p = (r1+r2)/400
- Classical p = 0.2875

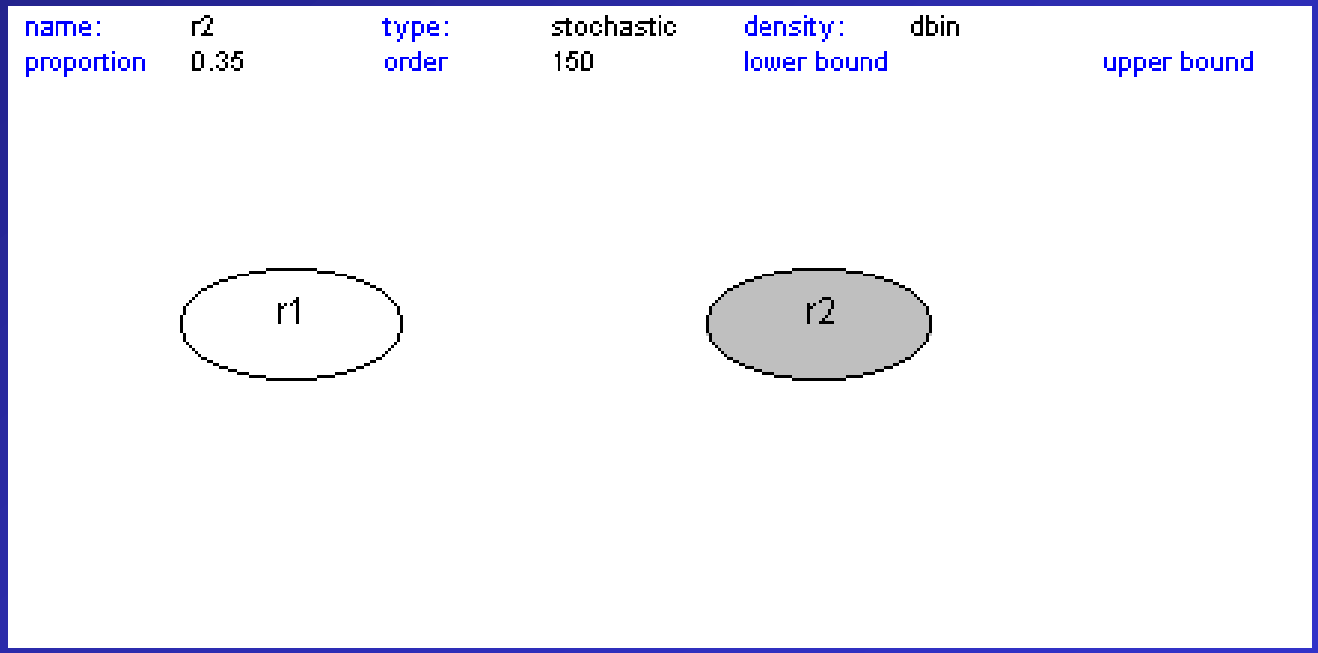
DoodleBUGS

- Start with r1 ~ Bin(0.25, 250) (stochastic node)



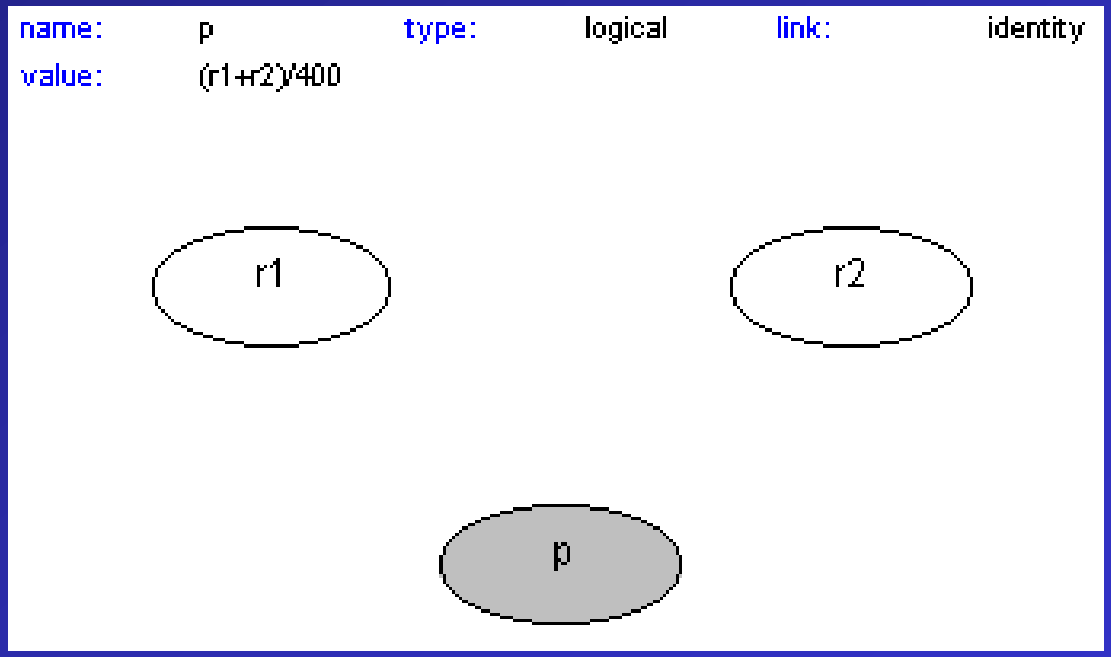
DoodleBUGS

- Add r2 ~ Bin(0.35, 150) (stochastic node)



Logical Nodes

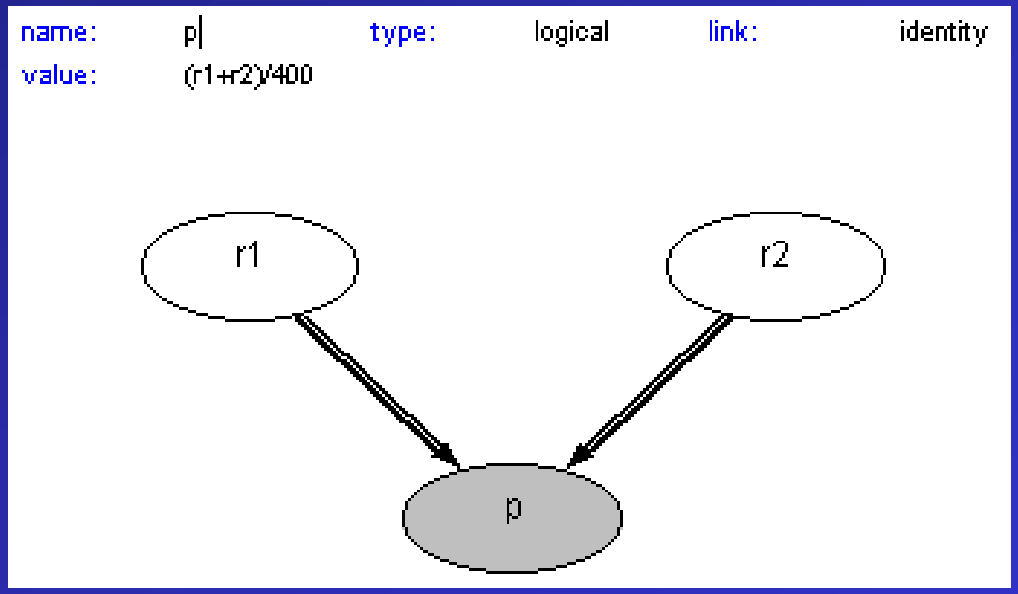
- Add p as a logical node



  - To define a logical node click on "type" for choices.

Logical Functions

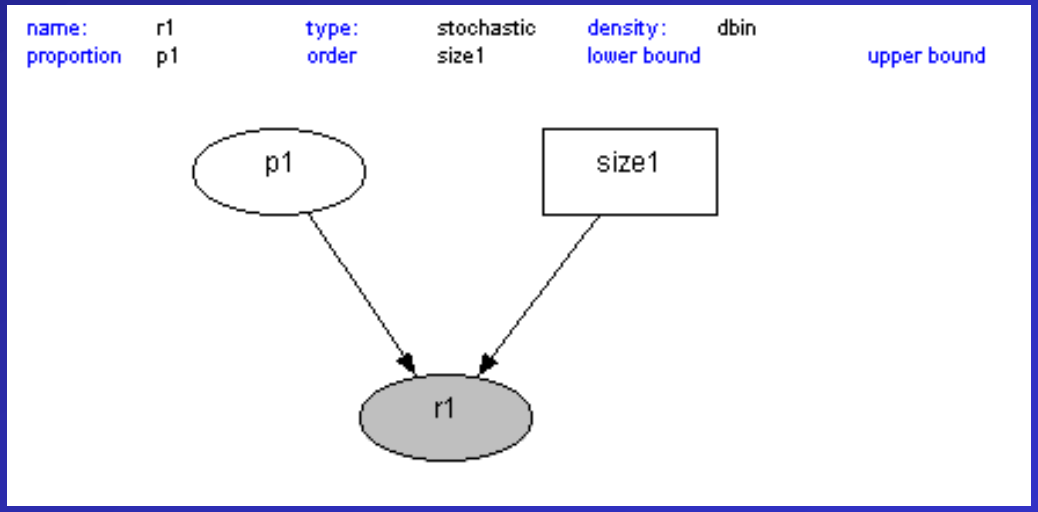
- Add "edges" for the logical relationship



  - Whilst node p is highlighted, CTRL + click in "parent nodes" r1 and r2 (hollow arrows ⇒ logical function)

Stochastic Nodes

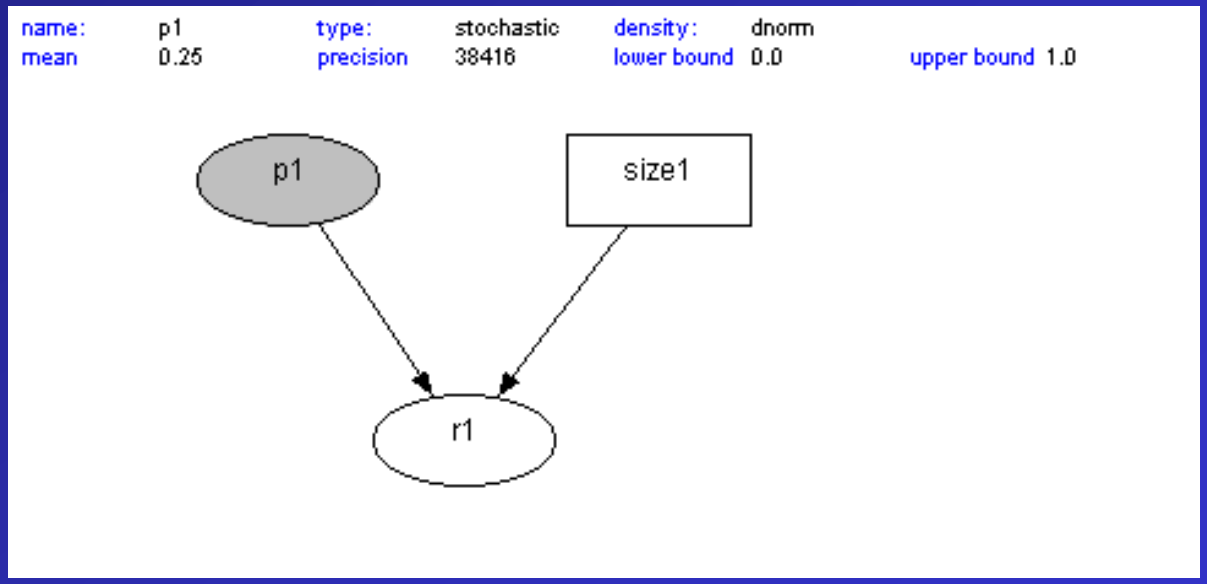
- Stochastic dependence
  - p1 ~ N(0.25, 0.000026) (i.e., p1 ~ [0.24, 0.26])
  - size1 = 250 (constant)



  - Single arrows for stochastic dependencies

Normal Distribution

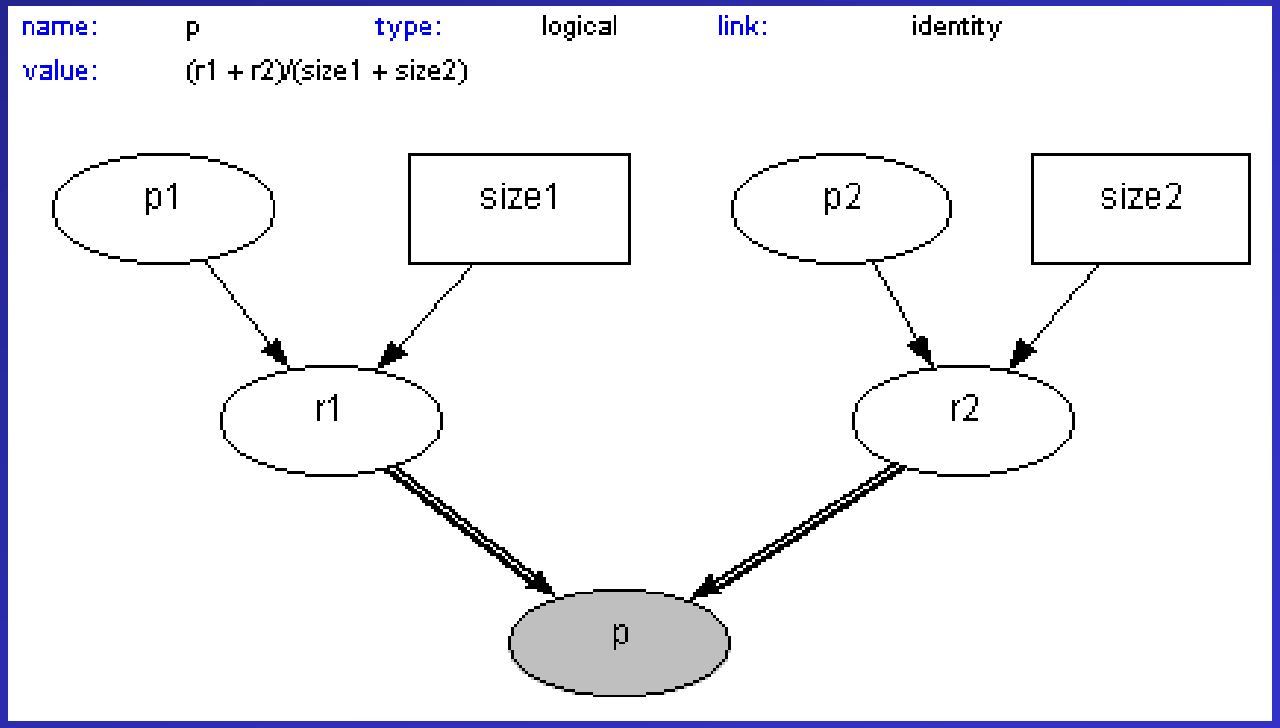
- Note the Normal distribution in BUGS is defined as N (mean, precision) where precision = 1/variance



  - Note that we can define upper and lower bounds so that the proportion is between 0 and 1.

DoodleBUGS Model

- Let us add these stochastic dependencies to our "logical" model

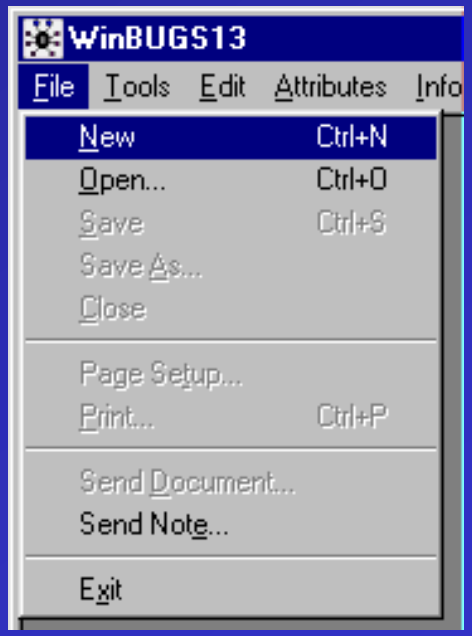


DoodleBUGS Model

- What is our model?
  - r1 ~ Bin (p1, size1)
  - p1 ~ N (0.25, 0.000026)
  - size1 = 250
  - r2 ~ Bin (p2, size2)
  - p2 ~ N (0.35, 0.000026)
  - size2 = 150

WinBUGS Modelling

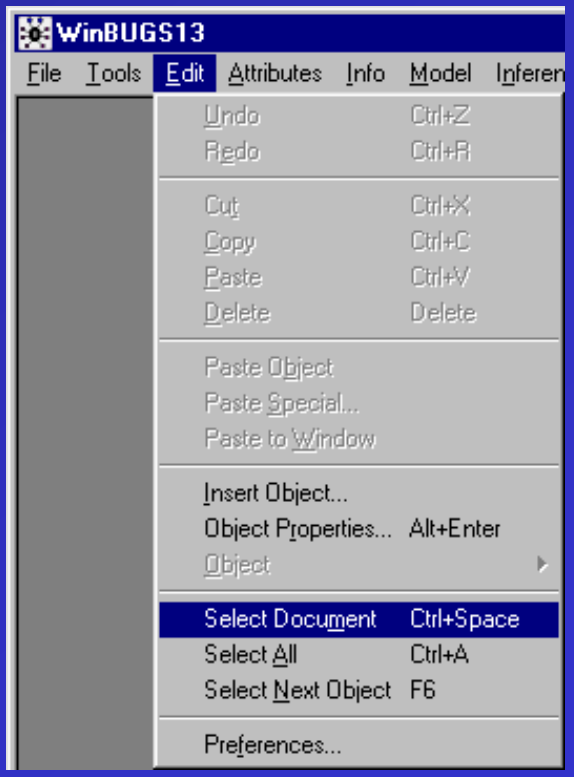
- Running our model in WinBUGS
  - Create a New document
    - Menu bar - File - New



- A New document window will appear

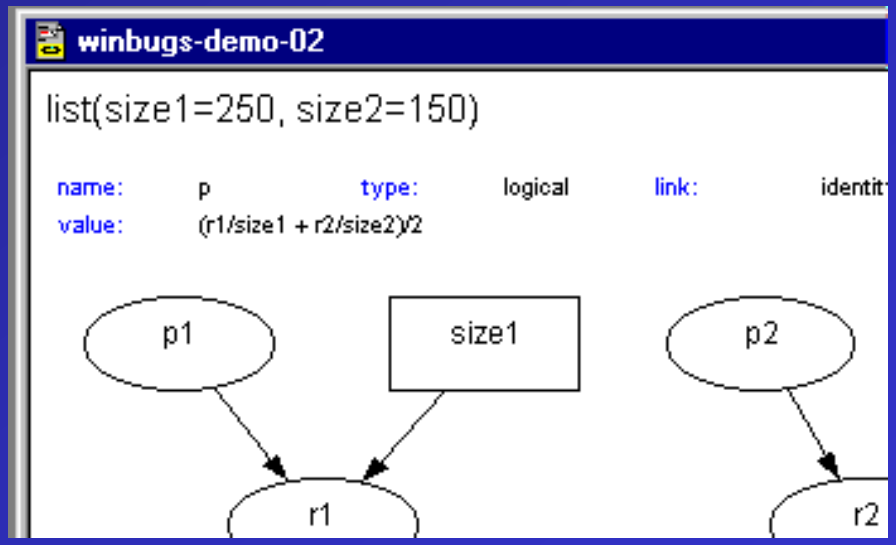
WinBUGS Document

- Select your Doodle from your Doodle Window
  - Menu bar - Edit - Select Document
- Copy your Doodle
  - Menu bar - Edit - Copy
- Paste it into your New Document
  - Menu bar - Edit - Paste



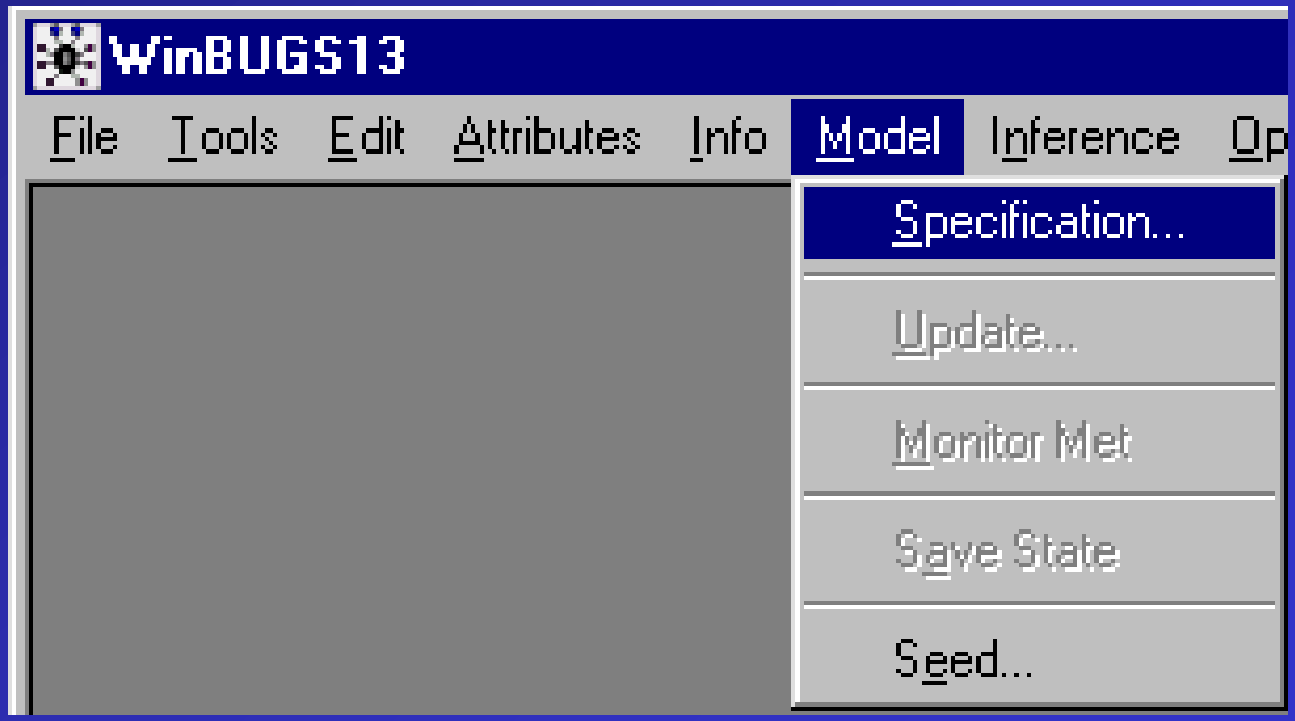
Model Data

- Before running we need to give BUGS some data
  - Type `list(size1=250, size2=150)` at the top (or the bottom) of your new document.



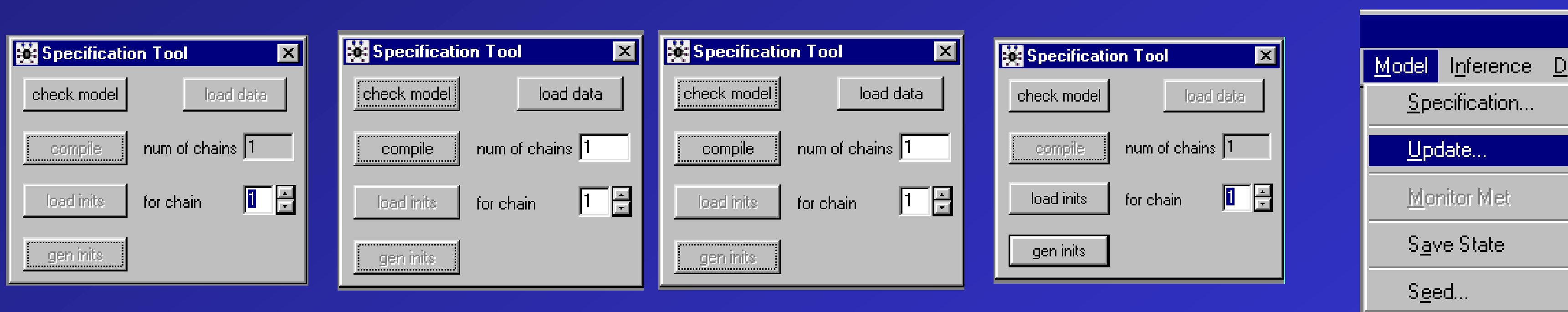
Running BUGS

- Use "Specification..." from the "Model" option on Menu Bar to run BUGS



Running BUGS

Check Model → Load Data → Compile Model → Initial Values → Update Sampler

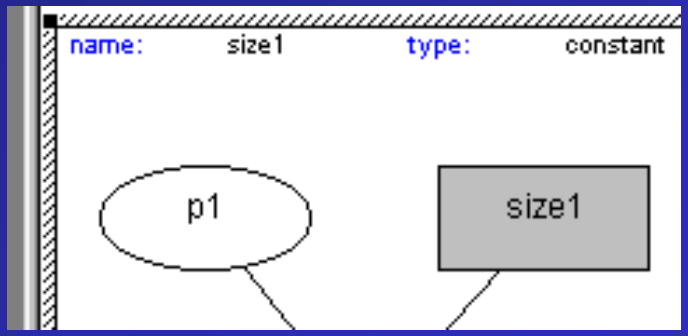


Checks Syntax

Start Sampler

Check Model

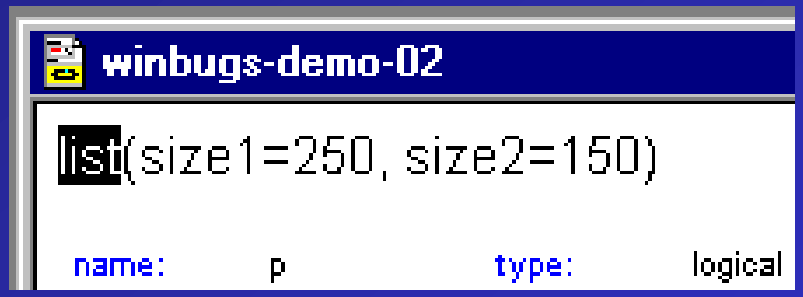
- Select the Doodle (note the hairy boarder)



- Menu bar - Model - Check model
- Note the message in bottom left hand corner

Load Data

- Highlight the word "list"



- Menu bar - Model - Data
- Bottom left hand corner

Compiling the Model

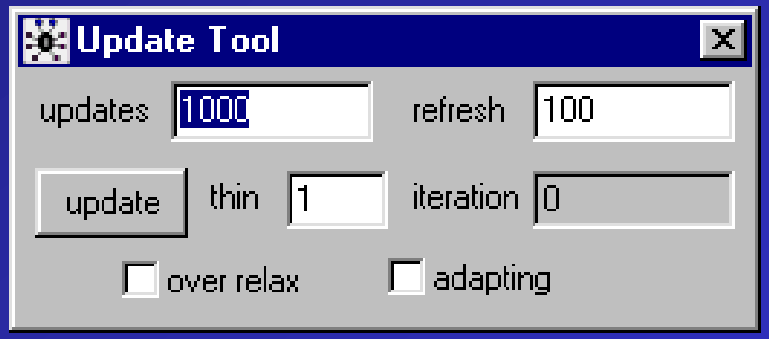
- Menu bar - Model - Compile
- Bottom left hand corner

Load Initial Values

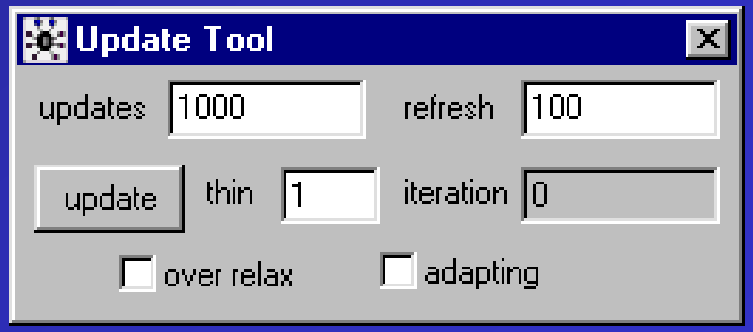
- Menu bar - Model - Gen inits
- Bottom left hand side

Update the Model

- Menu bar - Model - Update



- 1000 MCMC updates to be carried out.

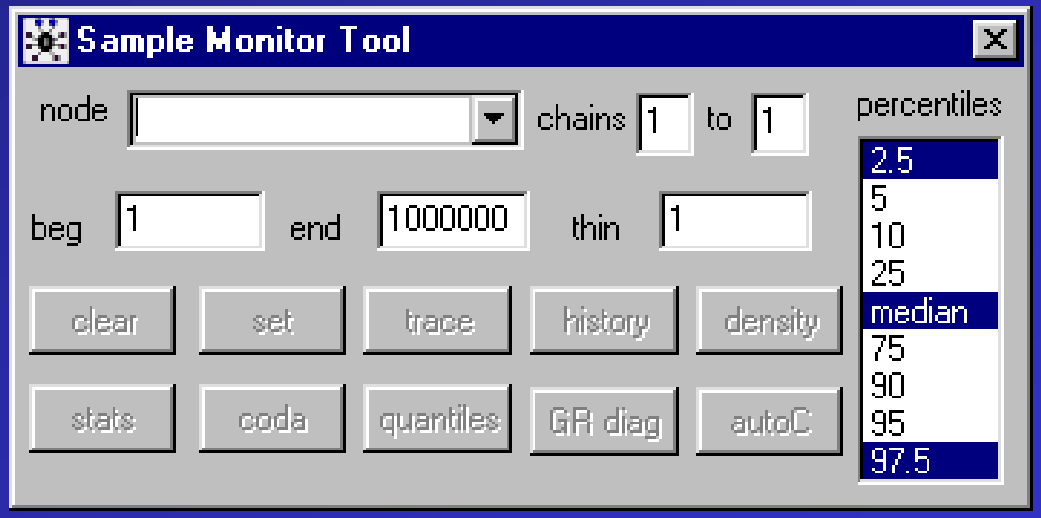


Burn In

- Model has been updated
- MCMC run did not store any data.
  - Used for the "burn in"
- Store values by "monitoring" them to
  - Draw inferences
  - Monitor MCMC run

Monitoring Nodes

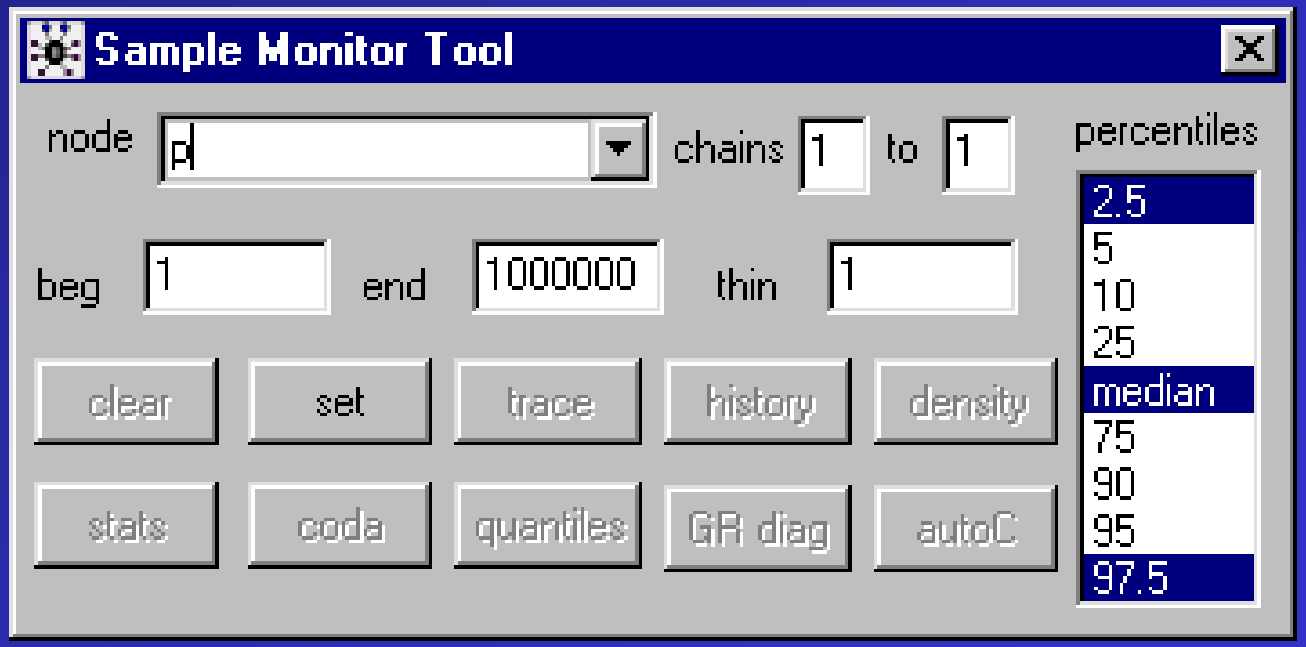
- Monitoring p our parameter of interest
- Menu bar - Inference - Samples...



- Sample Monitor Tool

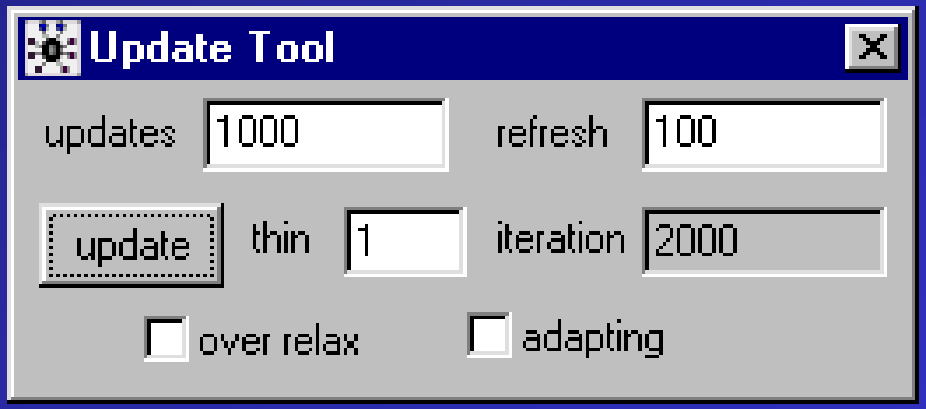
Monitoring Nodes

- Type name of node "p" to monitor
- Press "set"



Update & Monitor

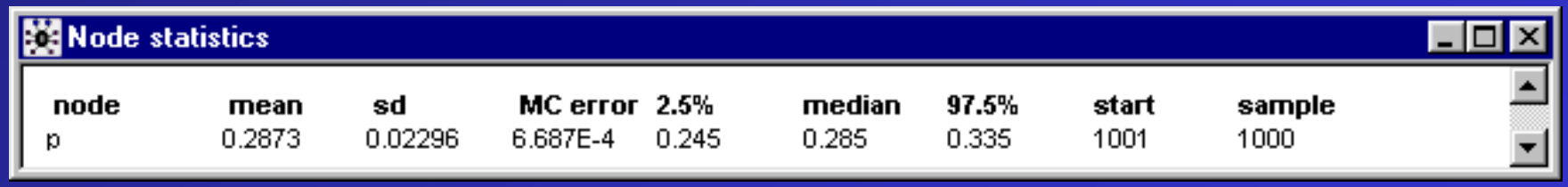
- Update model again



- 1000 values "monitored" of the MCMC run for p

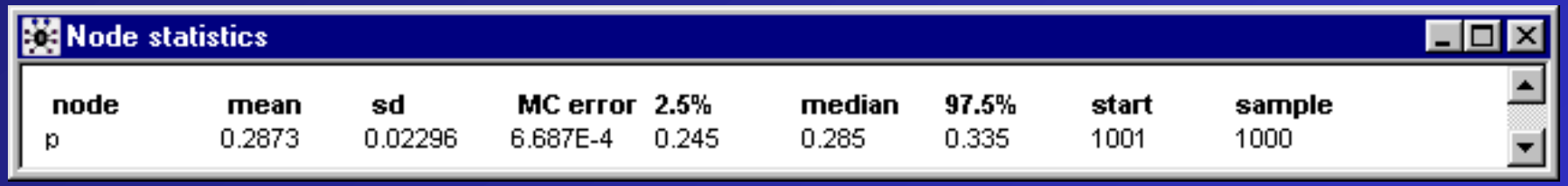
Summary Statistics

- Summary statistics
- Select "p" from the Sample Monitor Tool
- Press "stats" (Sample Monitor Tool)



- Node statistics window

Summary Statistics

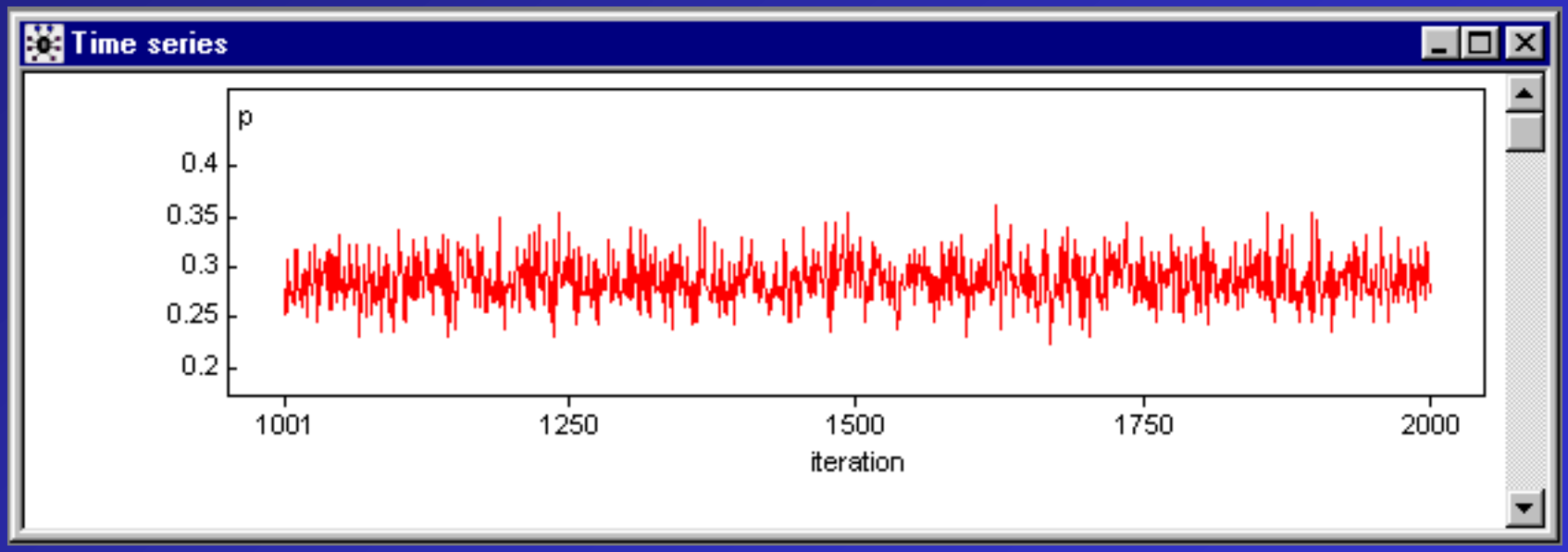

Node statistics

node	mean	sd	MC error	2.5%	median	97.5%	start	sample
p	0.2873	0.02296	6.687E-4	0.245	0.285	0.335	1001	1000

- Mean = 0.2873
- Median = 0.285 (usually more stable)
- 95% credible interval (0.245, 0.335)
- MCMC run size 1000

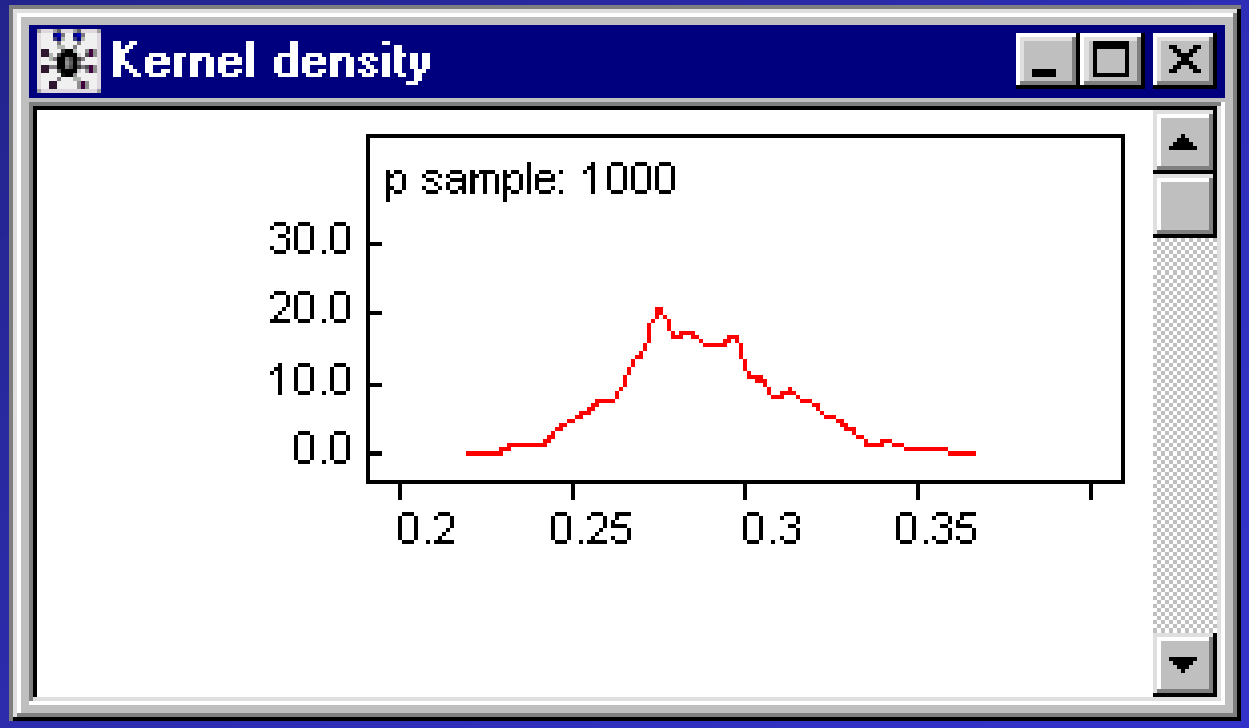
MCMC Time Series

- Press "History" in Sample Monitor Tool



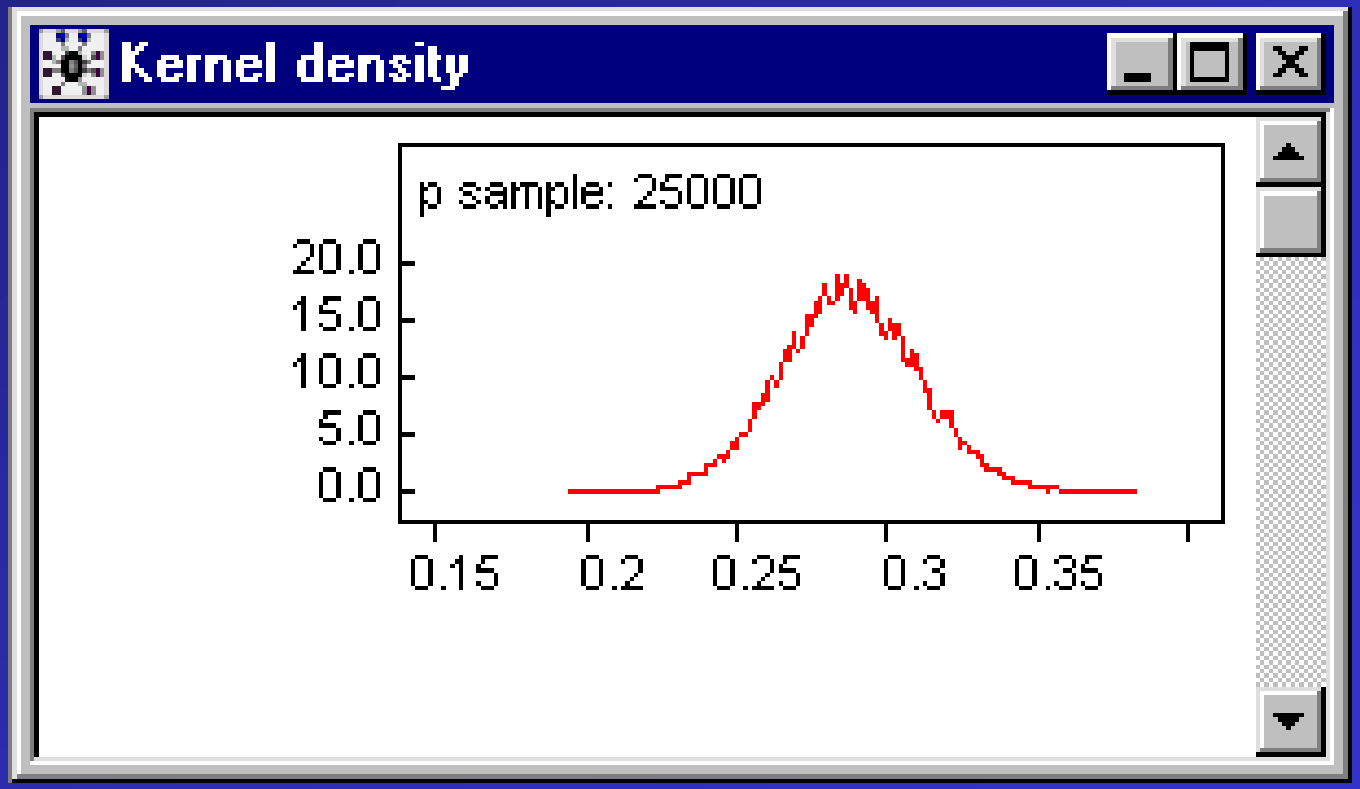
Kernel Density

- Press "Density" in the Sample Monitor Tool



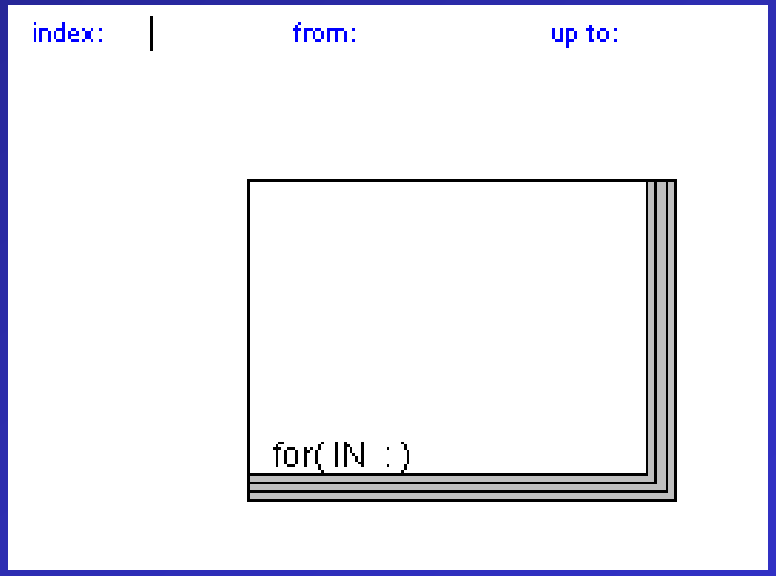
Kernel Density

- Increase monitored values to 25,000



Plates

- Creating a plate
  - CTRL + mouse click in Doodle Window



  - Deleting a plate: CTRL + Del

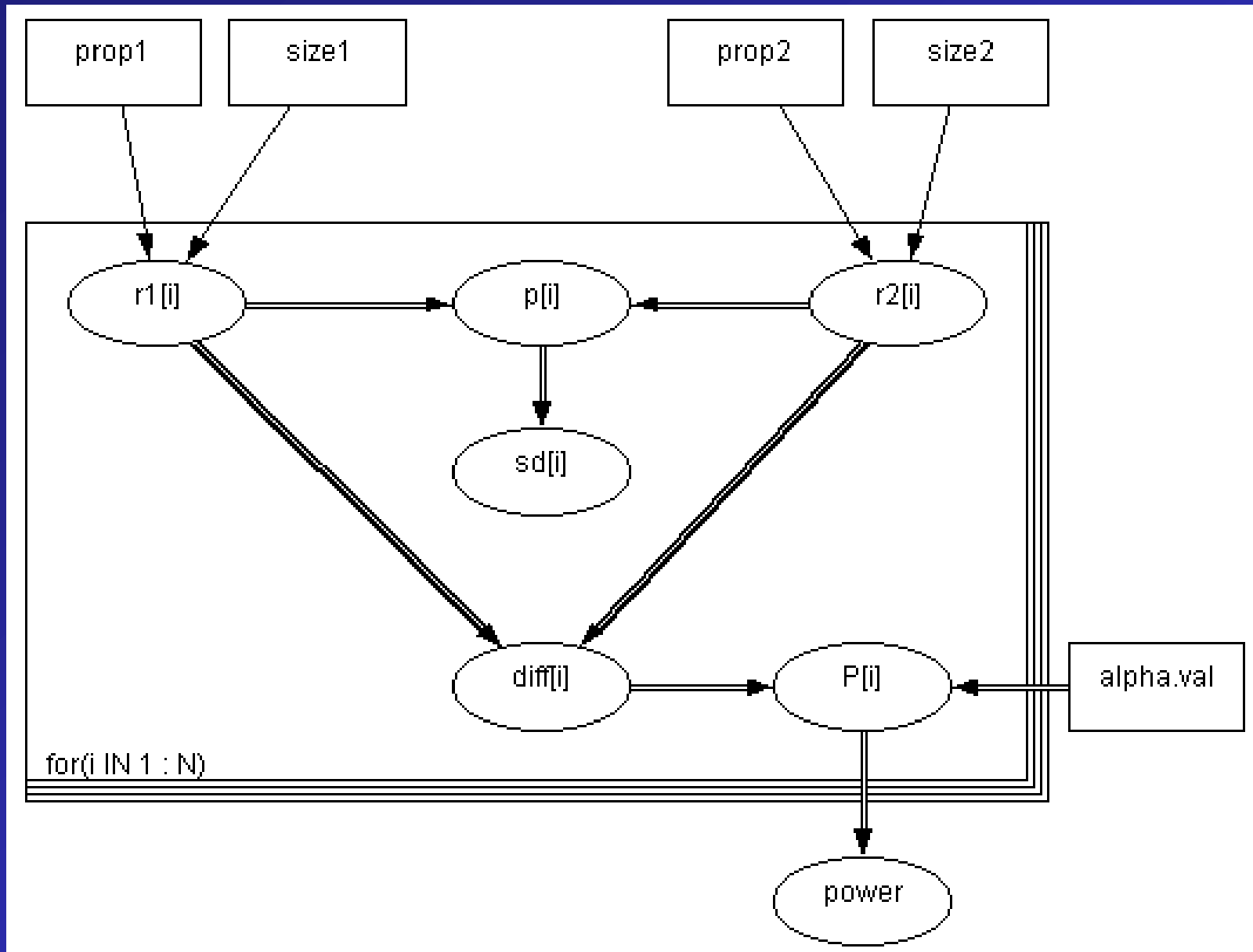
Plates

- Allow more complex structure, e.g.,
  - Repeated measures
  - Hierarchical models
- Extend our example to calculate power
  - r1 and r2 from Binomial distribution
  - Simulte r1 and r2 100 times per "update"
  - Calculate test statistic
  - Count number of times it falls in critical region

Test Statistic

- H_0: p1 = p2 = p vs H_1: p1 < p2
  - p1 = r1/size1 & p2 = r2/size2
- Test statistic $\dfrac{(p2 - p1)}{s.d.(p)}$

$$s.d.(p) = \sqrt{(p(1-p)(1/size1 + 1/size2))}$$


prop1
size1
prop2
size2
r1[i]
p[i]
r2[i]
sd[i]
diff[i]
P[i]
alpha.val
for(i IN 1 : N)
power

Power

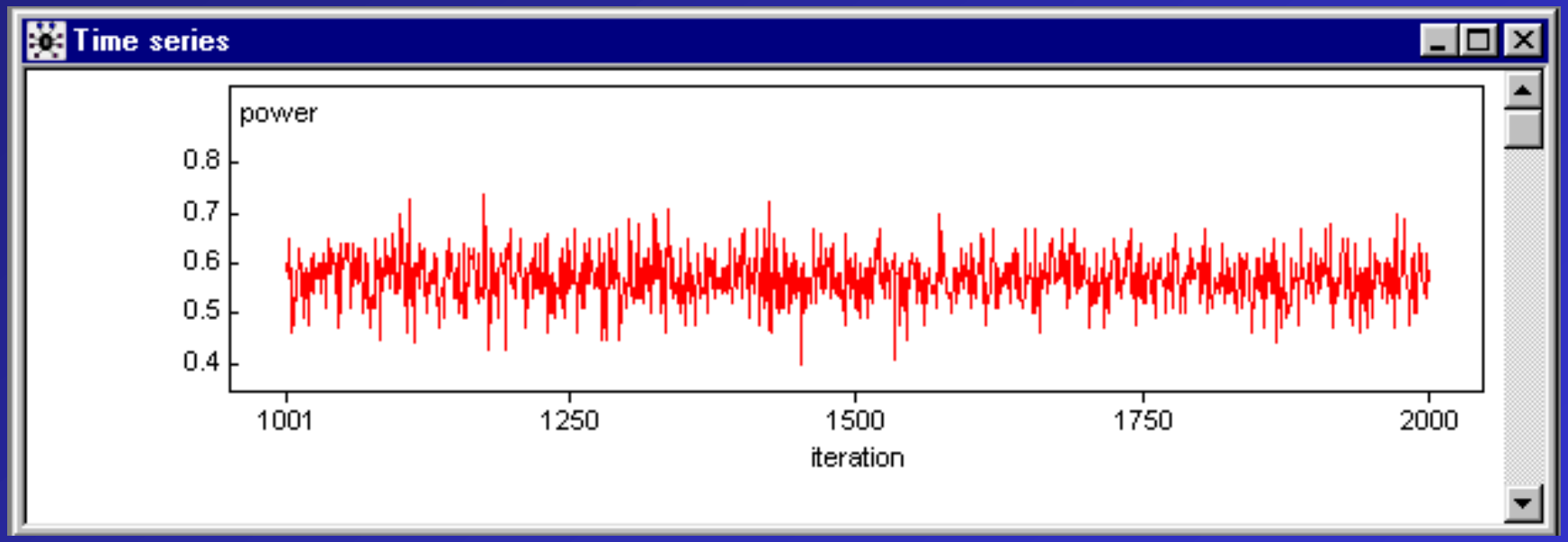
- Data
  - `list(prop1=.25, prop2=.35, size1=250,size2=150, N=100, alpha.val=1.96)`
- Results

Node statistics

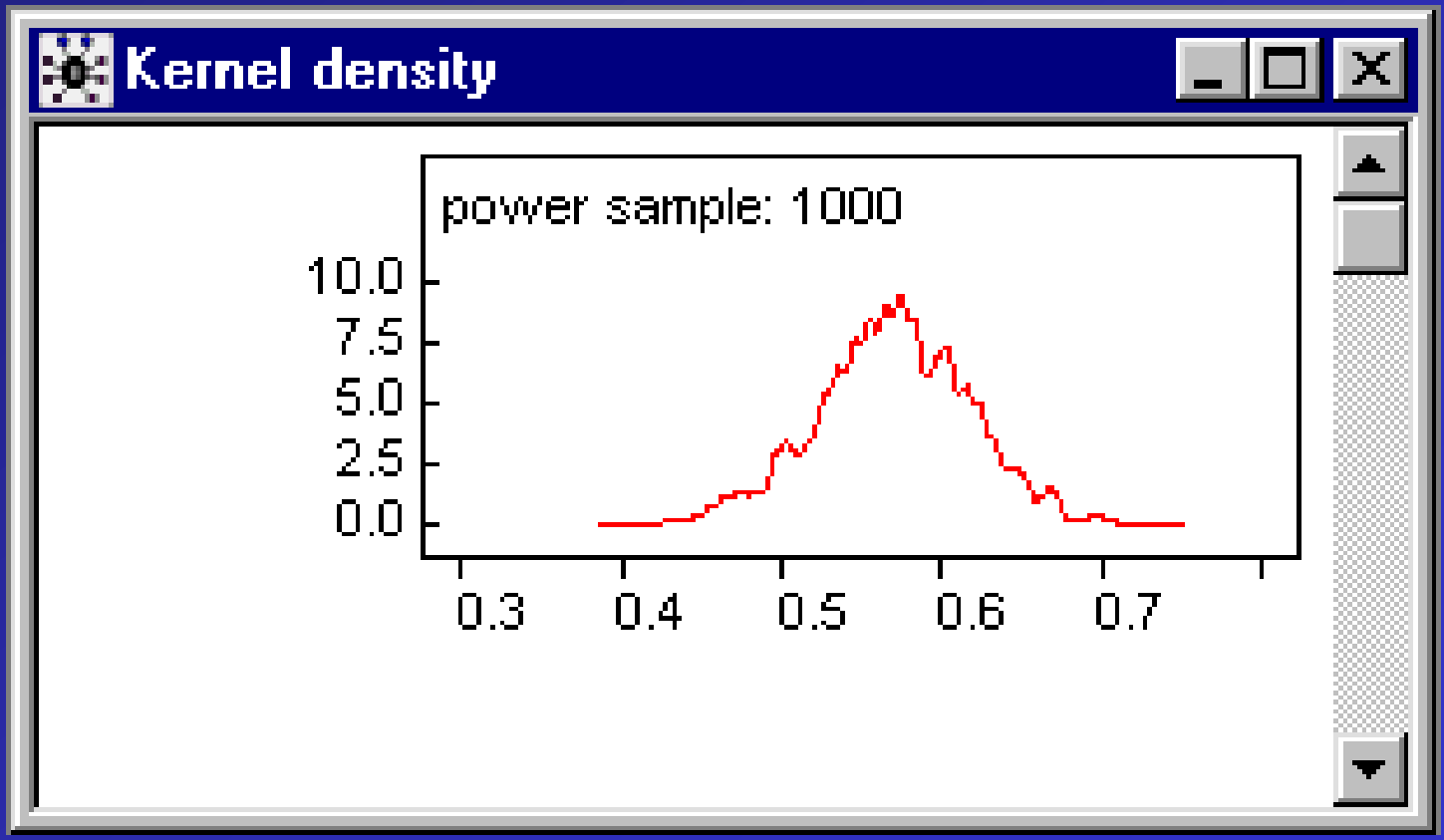
node	mean	sd	MC error	2.5%	median	97.5%	start	sample
power	0.5705	0.04899	0.001392	0.47	0.57	0.67	1001	1000

- Power = 57% (47%, 67%)

Power - History



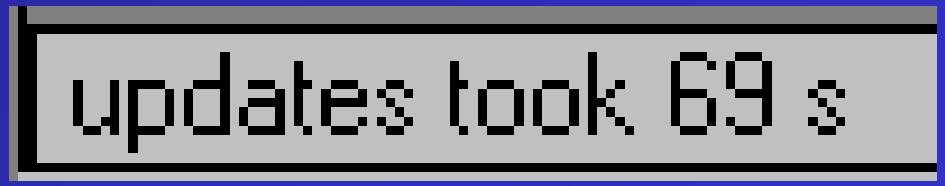
Power - Density



Updates

- Updating - Bottom left hand corner

- After updates finish



Summary

- BUGS is a power tool
  - Bayesian Analysis
  - Simulation Tool
- Graphical Models
  - Doodle BUGS
  - Simple representation of model
- Easy to use!