Graphics in R

- There are three plotting systems in R
  - base
    - Convenient, but hard to adjust after the plot is created
  - lattice
    - Good for creating conditioning plot
  - ggplot2
    - Powerful and flexible, many tunable feature, may require some time to master
- We will focus on the `ggplot2` package today

Basic Concepts of `ggplot2`

- An implementation of Grammar of Graphics by Leland Wilkinson, which represents abstraction of graphic objects and ideas
- Two ways of plotting
  - The `qplot` function: similar to the base plotting system with more features
  - The `ggplot` function: the engine of `qplot` - powerful, flexible and full featured
    - Make the plots in layers
      - Plot the data
      - Overlay a summary
      - Metadata and annotation

ggplot2 Components

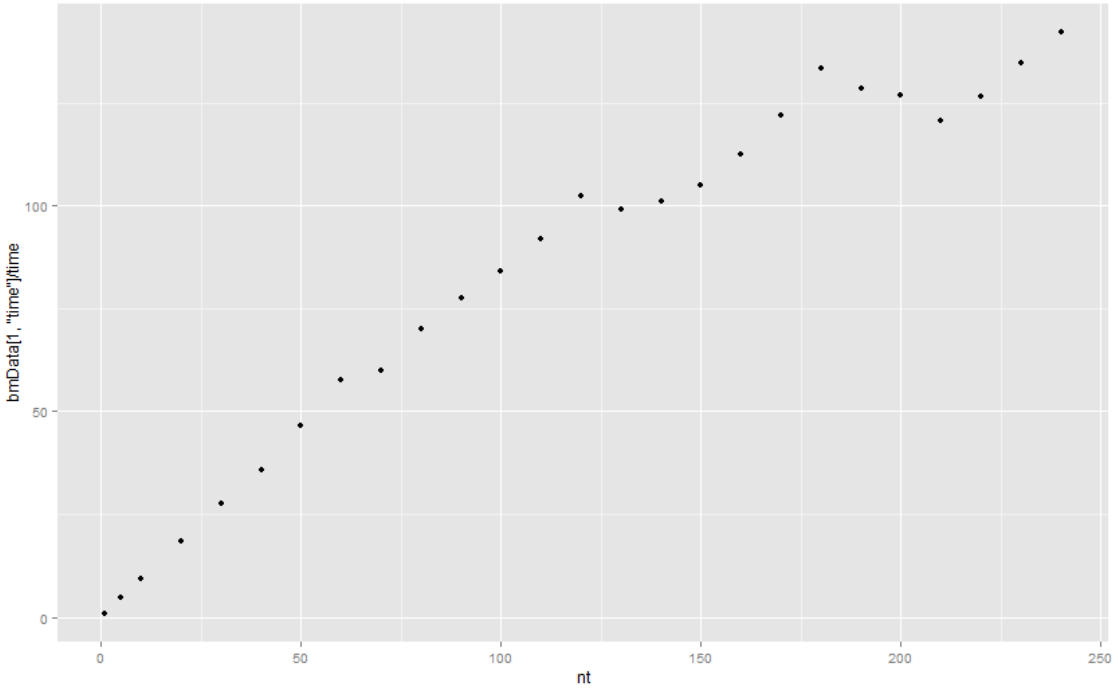
- **Data frame**
- **Aesthetic mappings**: how data are mapped to color, size
- **Geoms**: geometric objects like points, lines, shapes.
- **Facets**: for conditional plots.
- **Stats**: statistical transformations like binning and smoothing.
- **Scales**: what scale an aesthetic map uses (example: male = red, female = blue).
- **Coordinate system**

Example Data Frame

- Benchmark data on the SuperMIC cluster
  - Four columns: nt (number of threads), time, device ("mic" or "cpu"), node (number of nodes)

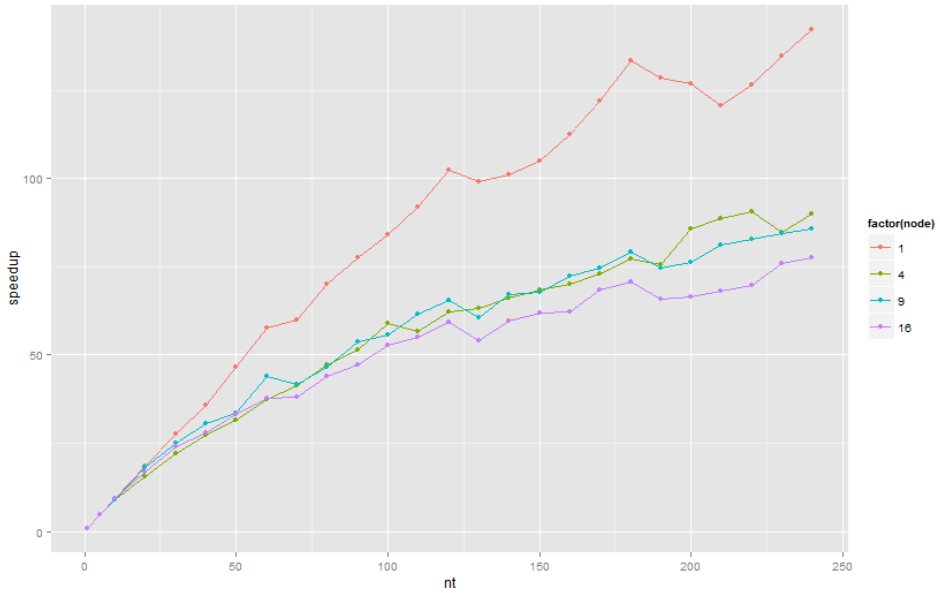
```
> head(bmData,3)
  nt       time device node
1  1 33358.562    mic    1
2  5  6894.032    mic    1
3 10  3566.916    mic    1
> tail(bmData,3)
    nt       time device node
182 18 10.237771    cpu   16
183 19  9.936815    cpu   16
184 20  9.452416    cpu   16
```

qplot Function

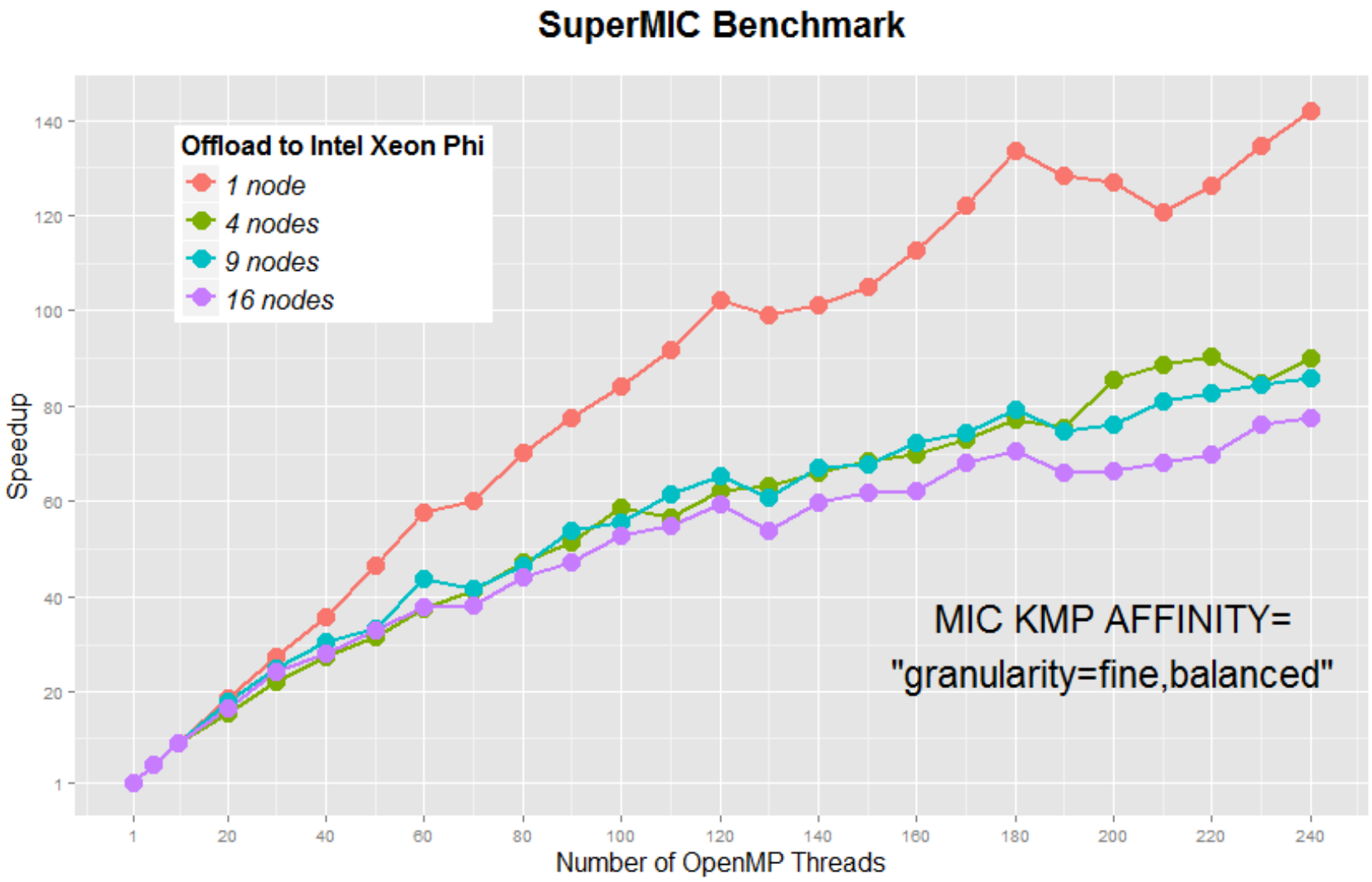



```
> qplot(nt,bmData[1,"time"]/time,
        data=subset(bmData,node==1 & device=="mic"))
```

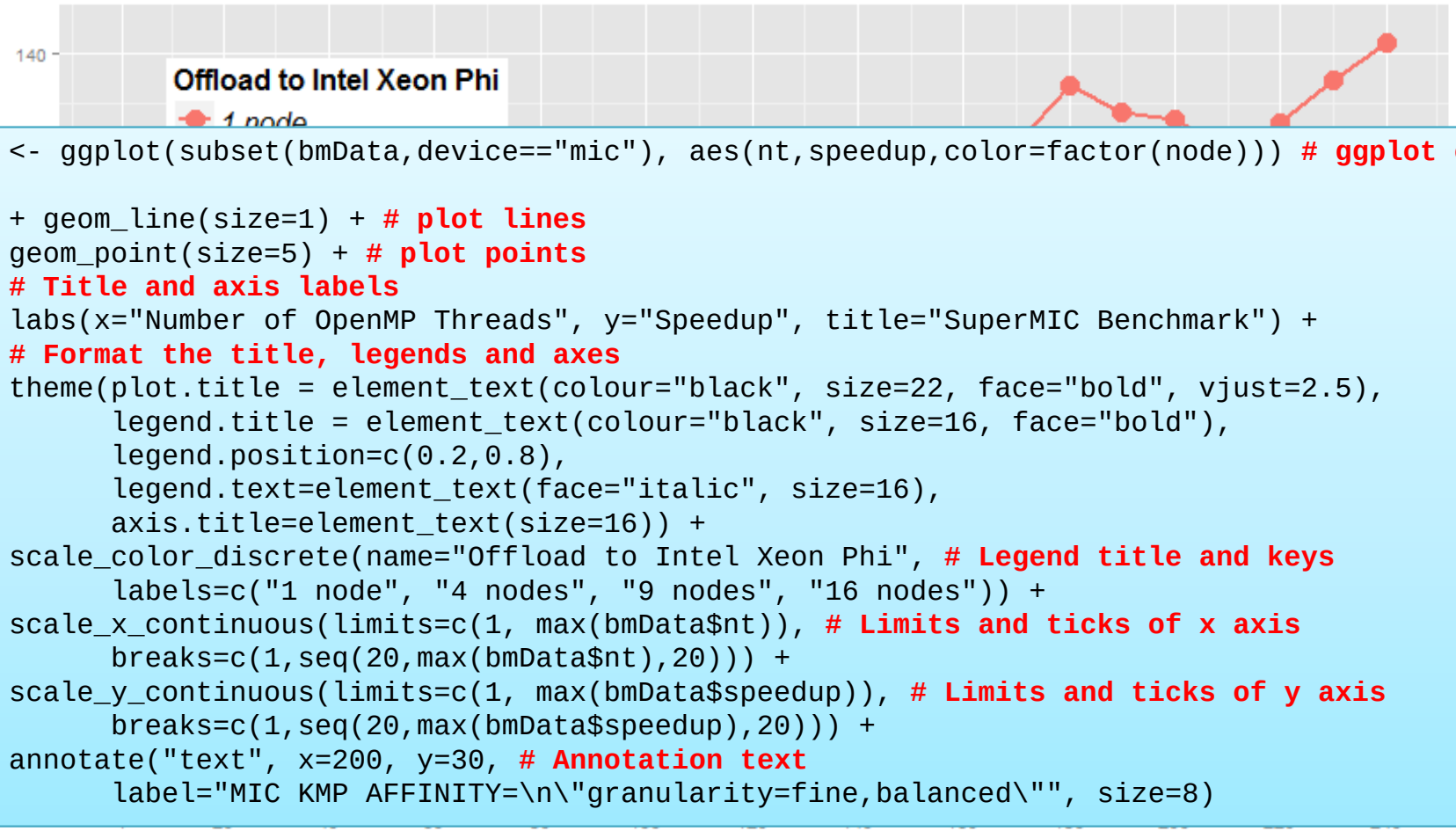
Using ggplot2




```
> g <- ggplot(subset(bmData,device=="mic"),
          aes(nt,speedup,color=factor(node)))
> summary(g)
data: nt, time, device, speedup, node [104x5]
mapping:  x = nt, y = speedup, colour = factor(node)
faceting: facet_null()
> g # No plot here yet
Error: No layers in plot
> g + geom_line() + geom_point() # Add geometric objects
```



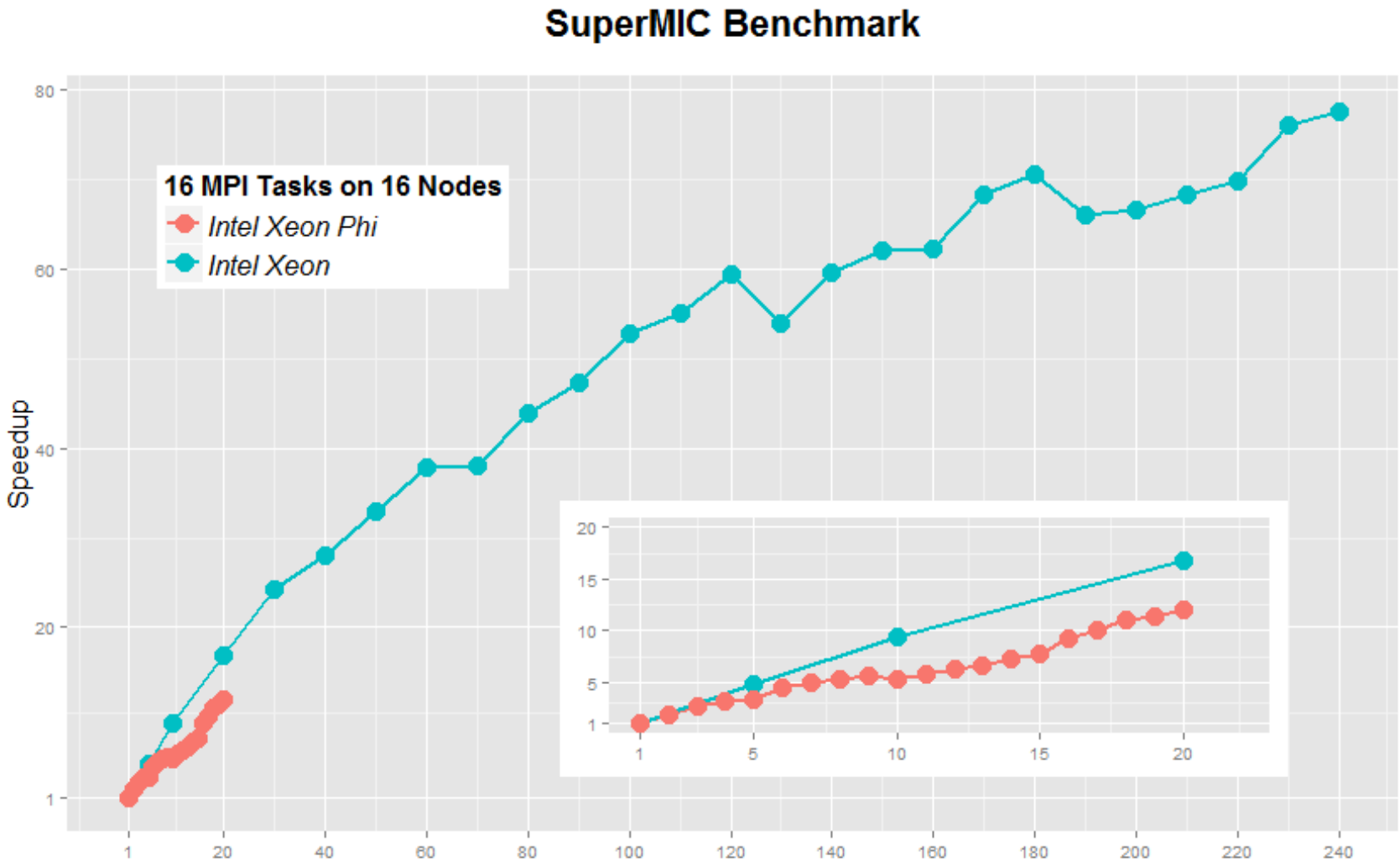
The same plot with decorations



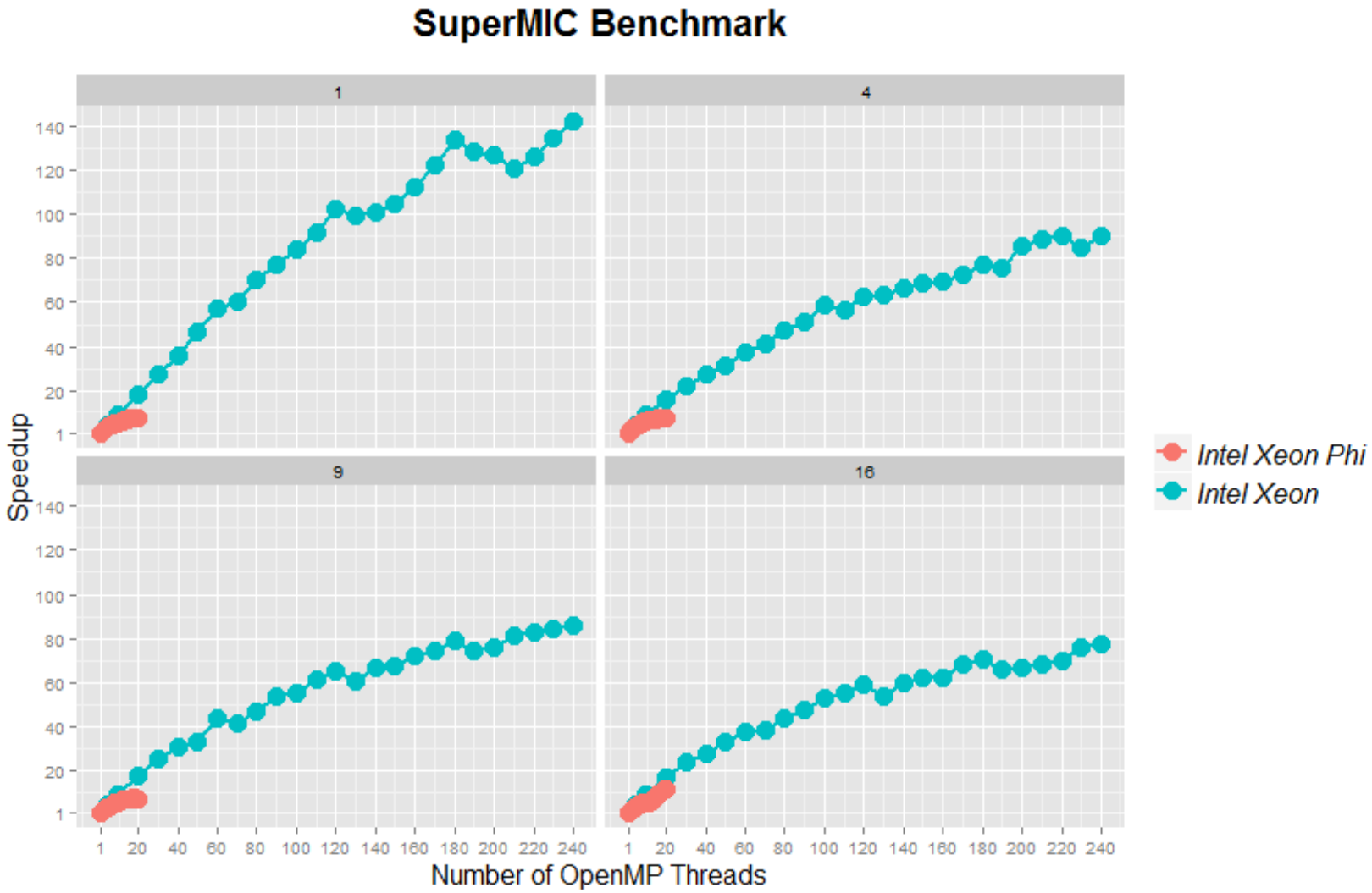

```
g <- ggplot(subset(bmData,device=="mic"), aes(nt,speedup,color=factor(node))) # ggplot call

g + geom_line(size=1) + # plot lines
  geom_point(size=5) + # plot points
  # Title and axis labels
  labs(x="Number of OpenMP Threads", y="Speedup", title="SuperMIC Benchmark") +
  # Format the title, legends and axes
  theme(plot.title = element_text(colour="black", size=22, face="bold", vjust=2.5),
        legend.title = element_text(colour="black", size=16, face="bold"),
        legend.position=c(0.2,0.8),
        legend.text=element_text(face="italic", size=16),
        axis.title=element_text(size=16)) +
  scale_color_discrete(name="Offload to Intel Xeon Phi", # Legend title and keys
        labels=c("1 node", "4 nodes", "9 nodes", "16 nodes")) +
  scale_x_continuous(limits=c(1, max(bmData$nt)), # Limits and ticks of x axis
        breaks=c(1,seq(20,max(bmData$nt),20))) +
  scale_y_continuous(limits=c(1, max(bmData$speedup)), # Limits and ticks of y axis
        breaks=c(1,seq(20,max(bmData$speedup),20))) +
  annotate("text", x=200, y=30, # Annotation text
        label="MIC KMP AFFINITY=\n\"granularity=fine,balanced\"", size=8)
```

Here's the code



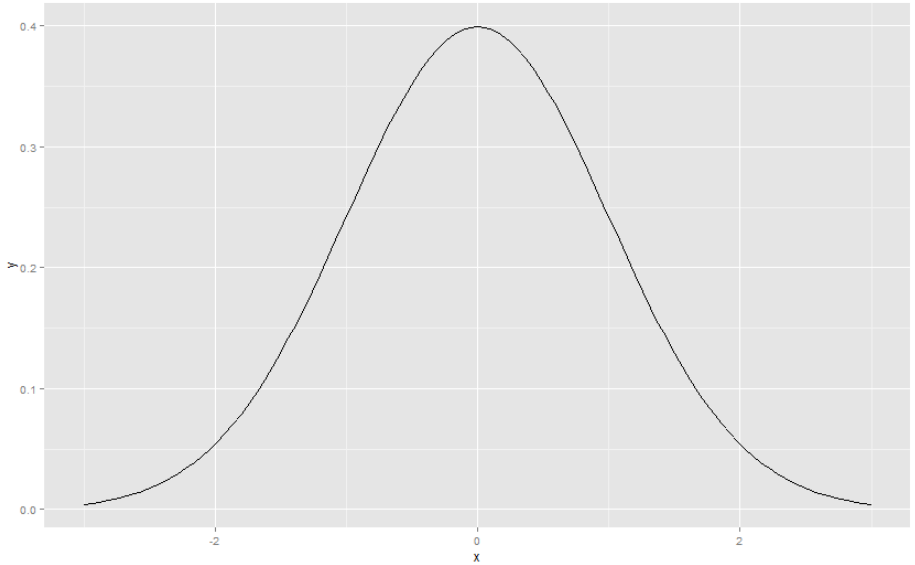
Plot with inset
(The code can be found in the script)



Plot with a 2x2 facet
(The code can be found in the script)

Plot Functions

- Plot a math function by using the `stat_function()` function




```
p <- ggplot(data.frame(x=c(-3,3)), aes(x=x))
p + stat_function(fun = dnorm)
```

Control The Output Format

- Graphic Devices
  - File devices
    - Bitmap: png, jpeg, etc.
    - Vector: pdf, svg, etc.
  - Screen devices (quartz, X11, etc.)
- Steps
  - Launch a graphic device
    - Functions: `png()`, `pdf()`, `svg()`, etc.
  - Make the plot
  - Close the device with `dev.off()` function

R Scripts

- We can put all the commands in a script
- Run R scripts with the `Rscript` command

```
[lyan1@qb4 Gnuplot-training]$ ls
benchmark.R  map3d.eps  map3d.pdf      multiplot.gpl  time-01-node-smic.dat  time-09-node-smic.dat
input3d.dat  map3d.gpl  multiplot.eps  multiplot.pdf  time-04-node-smic.dat  time-16-node-smic.dat
[lyan1@qb4 Gnuplot-training]$ Rscript benchmark.R
Warning messages:
1: Removed 22 rows containing missing values (geom_path).
2: Removed 22 rows containing missing values (geom_point).
[lyan1@qb4 Gnuplot-training]$ ls -tr
input3d.dat  map3d.pdf             time-04-node-smic.dat  multiplot.eps  smic_benchmark_1.pdf
map3d.gpl    multiplot.gpl         time-09-node-smic.dat  multiplot.pdf  smic_benchmark_2.svg
map3d.eps    time-01-node-smic.dat time-16-node-smic.dat  benchmark.R    smic_benchmark_3.png
```