A Route to the Future of Network Management

Monitoring the US Lattice for Quantum Chromo Dynamics

BY WARREN FAY

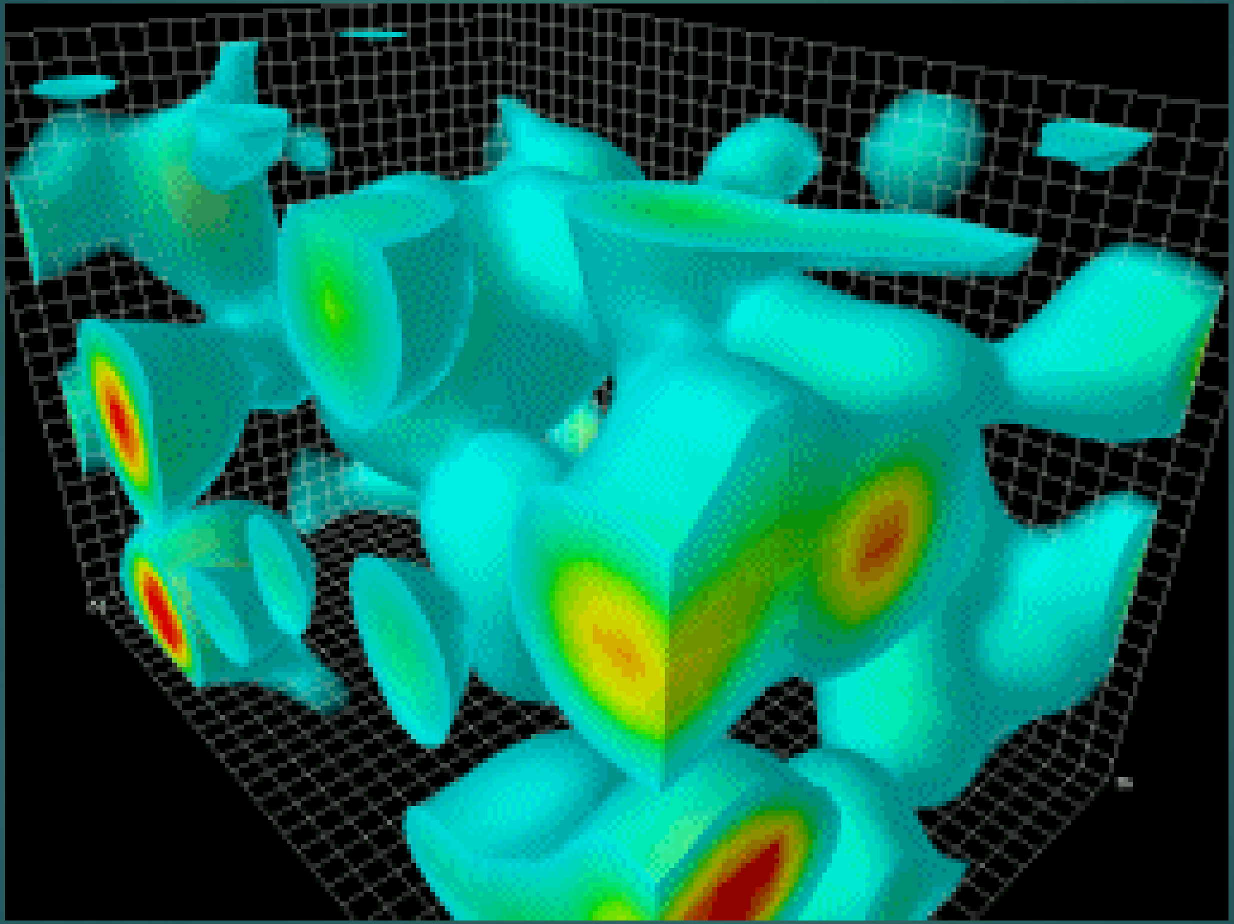
MENTOR: AMITOJ SINGH

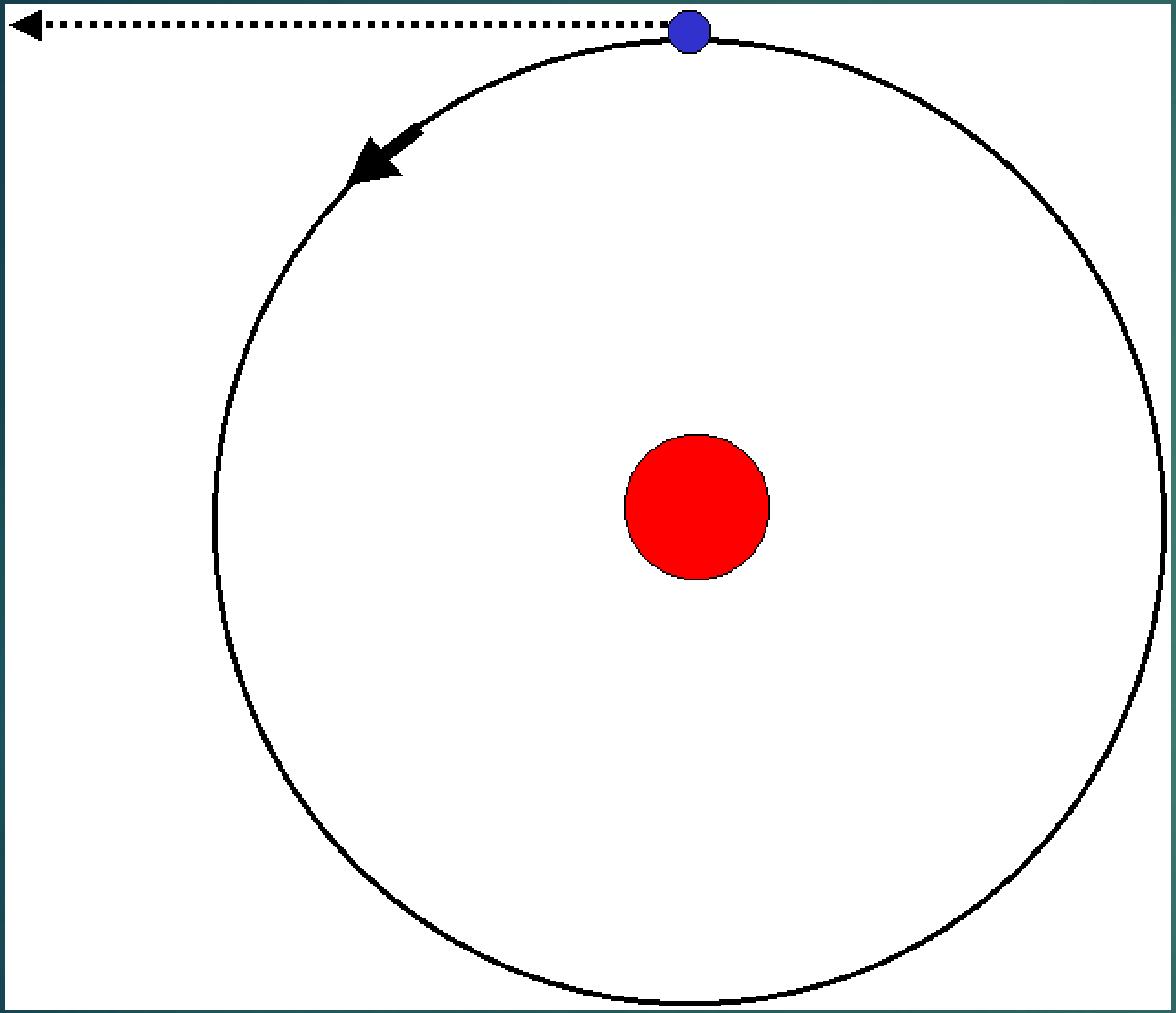
US Lattice for Quantum Chromo Dynamics

Floating-point Operations Per Second

Cluster	Processor	Nodes	DWF Performance	asqtad Performance
qcd	2.8GHz Single CPU Single Core P4E	127	1400 MFlops/node	1017 MFlops/node
pion	3.2GHz Single CPU Single Core Pentium 640	486	1729 MFlops/node	1594 MFlops/node
kaon	2.0GHz Dual CPU Dual Core Opteron	600	4703 MFlops/node	3832 MFlops/node
jpsi	2.1GHz Dual CPU Quad Core Opteron	856	10061 MFlops/node	9563 MFlops/node
ds	2GHz Quad CPU Eight Core Opteron	420	51520 MFlops/node	50553 MFlops/node

What is the LQCD used for?





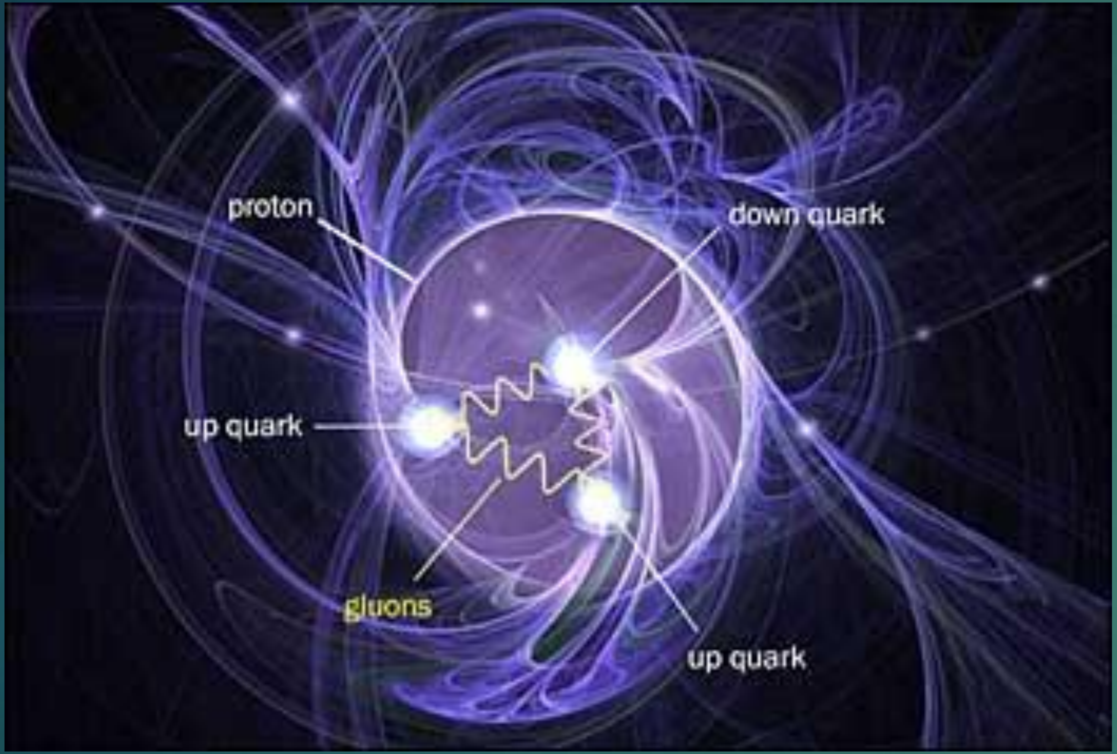
$$F = G\frac{m_1 m_2}{R^2}$$

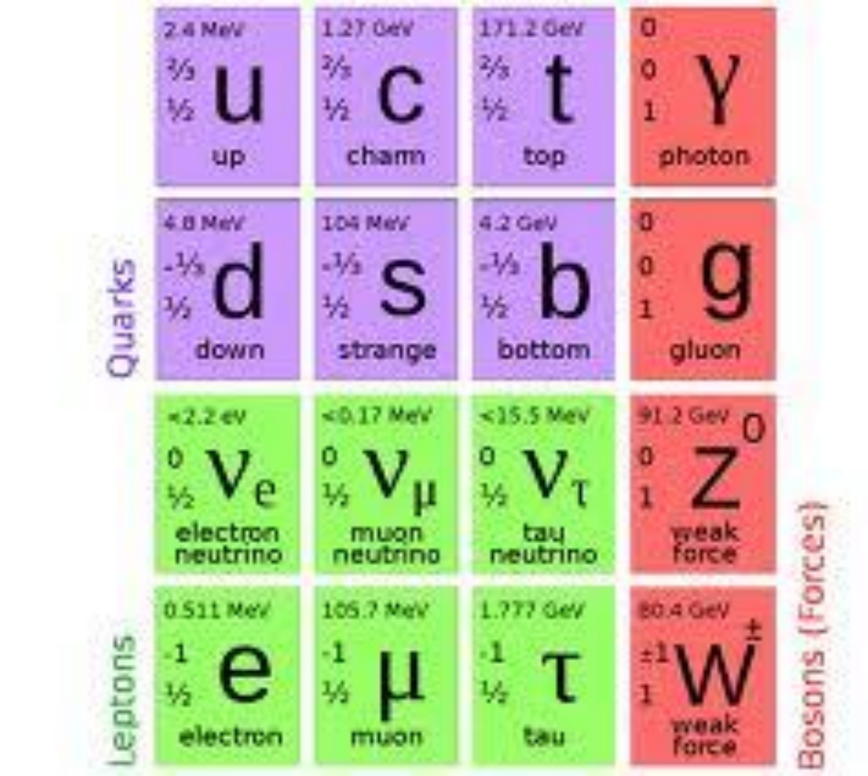
$$
\begin{aligned}
&-\tfrac{1}{2}\partial_\nu g^a_\mu \partial_\nu g^a_\mu - g_s f^{abc}\partial_\mu g^a_\nu g^b_\mu g^c_\nu - \tfrac{1}{4} g_s^2 f^{abc} f^{ade} g^b_\mu g^c_\nu g^d_\mu g^e_\nu + \\
&\tfrac{1}{2} i g_s^2 (\bar{q}^\sigma_i \gamma^\mu q^\sigma_j) g^a_\mu + \bar{G}^a \partial^2 G^a + g_s f^{abc} \partial_\mu \bar{G}^a G^b g^c_\mu - \partial_\nu W^+_\mu \partial_\nu W^-_\mu - \\
&M^2 W^+_\mu W^-_\mu - \tfrac{1}{2}\partial_\nu Z^0_\mu \partial_\nu Z^0_\mu - \tfrac{1}{2c_w^2} M^2 Z^0_\mu Z^0_\mu - \tfrac{1}{2}\partial_\mu A_\nu \partial_\mu A_\nu - \tfrac{1}{2}\partial_\mu H \partial_\mu H - \\
&\tfrac{1}{2} m_h^2 H^2 - \partial_\mu \phi^+ \partial_\mu \phi^- - M^2 \phi^+ \phi^- - \tfrac{1}{2}\partial_\mu \phi^0 \partial_\mu \phi^0 - \tfrac{1}{2c_w^2} M \phi^0 \phi^0 - \beta_h [\tfrac{2M^2}{g^2} + \\
&\tfrac{2M}{g} H + \tfrac{1}{2}(H^2 + \phi^0\phi^0 + 2\phi^+\phi^-)] + \tfrac{2M^4}{g^2}\alpha_h - i g c_w [\partial_\nu Z^0_\mu (W^+_\mu W^-_\nu - \\
&W^+_\nu W^-_\mu) - Z^0_\nu (W^+_\mu \partial_\nu W^-_\mu - W^-_\mu \partial_\nu W^+_\mu) + Z^0_\mu (W^+_\nu \partial_\nu W^-_\mu - \\
&W^-_\nu \partial_\nu W^+_\mu)] - i g s_w [\partial_\nu A_\mu (W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - A_\nu (W^+_\mu \partial_\nu W^-_\mu - \\
&W^-_\mu \partial_\nu W^+_\mu) + A_\mu (W^+_\nu \partial_\nu W^-_\mu - W^-_\nu \partial_\nu W^+_\mu)] - \tfrac{1}{2} g^2 W^+_\mu W^-_\mu W^+_\nu W^-_\nu + \\
&\tfrac{1}{2} g^2 W^+_\mu W^-_\nu W^+_\mu W^-_\nu + g^2 c_w^2 (Z^0_\mu W^+_\mu Z^0_\nu W^-_\nu - Z^0_\mu Z^0_\mu W^+_\nu W^-_\nu) + \\
&g^2 s_w^2 (A_\mu W^+_\mu A_\nu W^-_\nu - A_\mu A_\mu W^+_\nu W^-_\nu) + g^2 s_w c_w [A_\mu Z^0_\nu (W^+_\mu W^-_\nu - \\
&W^+_\nu W^-_\mu) - 2 A_\mu Z^0_\mu W^+_\nu W^-_\nu] - g\alpha [H^3 + H\phi^0\phi^0 + 2H\phi^+\phi^-] - \\
&\tfrac{1}{8} g^2 \alpha_h [H^4 + (\phi^0)^4 + 4(\phi^+\phi^-)^2 + 4(\phi^0)^2 \phi^+\phi^- + 4H^2\phi^+\phi^- + 2(\phi^0)^2 H^2] - \\
&g M W^+_\mu W^-_\mu H - \tfrac{1}{2} g \tfrac{M}{c_w^2} Z^0_\mu Z^0_\mu H - \tfrac{1}{2} i g [W^+_\mu (\phi^0 \partial_\mu \phi^- - \phi^- \partial_\mu \phi^0) - \\
&W^-_\mu (\phi^0 \partial_\mu \phi^+ - \phi^+ \partial_\mu \phi^0)] + \tfrac{1}{2} g [W^+_\mu (H \partial_\mu \phi^- - \phi^- \partial_\mu H) - W^-_\mu (H \partial_\mu \phi^+ - \\
&\phi^+ \partial_\mu H)] + \tfrac{1}{2} g \tfrac{1}{c_w} (Z^0_\mu (H \partial_\mu \phi^0 - \phi^0 \partial_\mu H) - i g \tfrac{s_w^2}{c_w} M Z^0_\mu (W^+_\mu \phi^- - W^-_\mu \phi^+) + \\
&i g s_w M A_\mu (W^+_\mu \phi^- - W^-_\mu \phi^+) - i g \tfrac{1-2c_w^2}{2c_w} Z^0_\mu (\phi^+ \partial_\mu \phi^- - \phi^- \partial_\mu \phi^+) + \\
&i g s_w A_\mu (\phi^+ \partial_\mu \phi^- - \phi^- \partial_\mu \phi^+) - \tfrac{1}{4} g^2 W^+_\mu W^-_\mu [H^2 + (\phi^0)^2 + 2\phi^+\phi^-] - \\
&\tfrac{1}{4} g^2 \tfrac{1}{c_w^2} Z^0_\mu Z^0_\mu [H^2 + (\phi^0)^2 + 2(2s_w^2 - 1)^2 \phi^+\phi^-] - \tfrac{1}{2} g^2 \tfrac{s_w^2}{c_w} Z^0_\mu \phi^0 (W^+_\mu \phi^- + \\
&W^-_\mu \phi^+) - \tfrac{1}{2} i g^2 \tfrac{s_w^2}{c_w} Z^0_\mu H (W^+_\mu \phi^- - W^-_\mu \phi^+) + \tfrac{1}{2} g^2 s_w A_\mu \phi^0 (W^+_\mu \phi^- + \\
&W^-_\mu \phi^+) + \tfrac{1}{2} i g^2 s_w A_\mu H (W^+_\mu \phi^- - W^-_\mu \phi^+) - g^2 \tfrac{s_w}{c_w} (2c_w^2 - 1) Z^0_\mu A_\mu \phi^+\phi^- - \\
&g^1 s_w^2 A_\mu A_\mu \phi^+\phi^- - \bar{e}^\lambda (\gamma\partial + m_e^\lambda) e^\lambda - \bar{\nu}^\lambda \gamma\partial \nu^\lambda - \bar{u}_j^\lambda (\gamma\partial + m_u^\lambda) u_j^\lambda - \\
&\bar{d}_j^\lambda (\gamma\partial + m_d^\lambda) d_j^\lambda + i g s_w A_\mu [-(\bar{e}^\lambda \gamma^\mu e^\lambda) + \tfrac{2}{3}(\bar{u}_j^\lambda \gamma^\mu u_j^\lambda) - \tfrac{1}{3}(\bar{d}_j^\lambda \gamma^\mu d_j^\lambda)] + \\
&\tfrac{ig}{4c_w} Z^0_\mu [(\bar{\nu}^\lambda \gamma^\mu (1+\gamma^5) \nu^\lambda) + (\bar{e}^\lambda \gamma^\mu (4s_w^2 - 1 - \gamma^5) e^\lambda) + (\bar{u}_j^\lambda \gamma^\mu (\tfrac{4}{3}s_w^2 - \\
&1 - \gamma^5) u_j^\lambda) + (\bar{d}_j^\lambda \gamma^\mu (1 - \tfrac{8}{3}s_w^2 - \gamma^5) d_j^\lambda)] + \tfrac{ig}{2\sqrt{2}} W^+_\mu [(\bar{\nu}^\lambda \gamma^\mu (1+\gamma^5) e^\lambda) + \\
&(\bar{u}_j^\lambda \gamma^\mu (1+\gamma^5) C_{\lambda\kappa} d_j^\kappa)] + \tfrac{ig}{2\sqrt{2}} W^-_\mu [(\bar{e}^\lambda \gamma^\mu (1+\gamma^5) \nu^\lambda) + (\bar{d}_j^\kappa C^\dagger_{\lambda\kappa} \gamma^\mu (1 + \\
&\gamma^5) u_j^\lambda)] + \tfrac{ig}{2\sqrt{2}} \tfrac{m_e^\lambda}{M} [-\phi^+ (\bar{\nu}^\lambda (1-\gamma^5) e^\lambda) + \phi^- (\bar{e}^\lambda (1+\gamma^5) \nu^\lambda)] - \\
&\tfrac{g}{2} \tfrac{m_e^\lambda}{M} [H (\bar{e}^\lambda e^\lambda) + i\phi^0 (\bar{e}^\lambda \gamma^5 e^\lambda)] + \tfrac{ig}{2M\sqrt{2}} \phi^+ [-m_d^\kappa (\bar{u}_j^\lambda C_{\lambda\kappa} (1-\gamma^5) d_j^\kappa) + \\
&m_u^\lambda (\bar{u}_j^\lambda C_{\lambda\kappa} (1+\gamma^5) d_j^\kappa] + \tfrac{ig}{2M\sqrt{2}} \phi^- [m_d^\lambda (\bar{d}_j^\lambda C^\dagger_{\lambda\kappa} (1+\gamma^5) u_j^\kappa) - m_u^\kappa (\bar{d}_j^\lambda C^\dagger_{\lambda\kappa} (1 - \\
&\gamma^5) u_j^\kappa] - \tfrac{g}{2} \tfrac{m_u^\lambda}{M} H (\bar{u}_j^\lambda u_j^\lambda) - \tfrac{g}{2} \tfrac{m_d^\lambda}{M} H (\bar{d}_j^\lambda d_j^\lambda) + \tfrac{ig}{2} \tfrac{m_u^\lambda}{M} \phi^0 (\bar{u}_j^\lambda \gamma^5 u_j^\lambda) - \\
&\tfrac{ig}{2} \tfrac{m_d^\lambda}{M} \phi^0 (\bar{d}_j^\lambda \gamma^5 d_j^\lambda) + \bar{X}^+ (\partial^2 - M^2) X^+ + \bar{X}^- (\partial^2 - M^2) X^- + \bar{X}^0 (\partial^2 - \\
&\tfrac{M^2}{c_w^2}) X^0 + \bar{Y} \partial^2 Y + i g c_w W^+_\mu (\partial_\mu \bar{X}^0 X^- - \partial_\mu \bar{X}^+ X^0) + i g s_w W^+_\mu (\partial_\mu \bar{Y} X^- - \\
&\partial_\mu \bar{X}^+ Y) + i g c_w W^-_\mu (\partial_\mu \bar{X}^- X^0 - \partial_\mu \bar{X}^0 X^+) + i g s_w W^-_\mu (\partial_\mu \bar{X}^- Y - \\
&\partial_\mu \bar{Y} X^+) + i g c_w Z^0_\mu (\partial_\mu \bar{X}^+ X^+ - \partial_\mu \bar{X}^- X^-) + i g s_w A_\mu (\partial_\mu \bar{X}^+ X^+ - \\
&\partial_\mu \bar{X}^- X^-) - \tfrac{1}{2} g M [\bar{X}^+ X^+ H + \bar{X}^- X^- H + \tfrac{1}{c_w^2} \bar{X}^0 X^0 H] + \\
&\tfrac{1-2c_w^2}{2c_w} i g M [\bar{X}^+ X^0 \phi^+ - \bar{X}^- X^0 \phi^-] + \tfrac{1}{2c_w} i g M [\bar{X}^0 X^- \phi^+ - \bar{X}^0 X^+ \phi^-] + \\
&i g M s_w [\bar{X}^0 X^- \phi^+ - \bar{X}^0 X^+ \phi^-] + \tfrac{1}{2} i g M [\bar{X}^+ X^+ \phi^0 - \bar{X}^- X^- \phi^0]
\end{aligned}
$$

$$
\begin{aligned}
L(\ldots) = & -\frac{1}{4g_s^2} G^{\mu\nu}_A(x) G_{A\mu\nu}(x) - \frac{1}{4g_w^2} W^{\mu\nu}_a(x) W_{a\mu\nu}(x) - \frac{1}{4g_y^2} V^{\mu\nu}(x) V_{\mu\nu}(x) + \\
& + [D^{(W,V)}_\mu \phi(x)]^\dagger D^{(W,V)\mu} \phi(x) - \lambda(\phi^\dagger(x)\phi(x) - \phi_o^2)^2 + \\
& + \bar{\psi}^{(l)}_{Li}(x) i\gamma^\mu (\partial_\mu + W_{a\mu}(x) T^a_w + V_\mu(x) Y_w) \psi^{(l)}_{Li}(x) + \\
& + \bar{\psi}^{(l)}_{Ri}(x) i\gamma^\mu (\partial_\mu + V_\mu(x) Y_w) \psi^{(l)}_{Ri}(x) + \\
& + \bar{\psi}^{(l)}_{Li}(x) \cdot \frac{\phi(x)}{\phi_o} M^{(l)}_{ij} \psi^{(l)}_{Rj}(x) + \bar{\psi}^{(l)}_{Ri}(x) M^{(l)\dagger}_{ij} \frac{\phi^\dagger(x)}{\phi_o} \cdot \psi^{(l)}_{Lj}(x) + \\
& + \bar{\psi}^{(q)}_{Li}(x) i\gamma^\mu (\partial_\mu + W_{a\mu}(x) T^a_w + V_\mu(x) Y_w + G_{A\mu}(x) T^A_s) \psi^{(q)}_{Li}(x) + \\
& + \bar{\psi}^{(q)}_{Ri}(x) i\gamma^\mu (\partial_\mu + V_\mu(x) Y_w + G_{A\mu}(x) T^A_s) \psi^{(q)}_{Ri}(x) + \\
& + \bar{\tilde{\psi}}^{(q)}_{Ri}(x) i\gamma^\mu (\partial_\mu + V_\mu(x) Y_w + G_{A\mu}(x) T^A_s) \tilde{\psi}^{(q)}_{Ri}(x) + \\
& + \bar{\psi}^{(q)}_{Li}(x) \cdot \frac{\phi(x)}{\phi_o} M^{(q)}_{ij} \psi^{(q)}_{Rj}(x) + \bar{\psi}^{(q)}_{Ri}(x) M^{(q)\dagger}_{ij} \frac{\phi^\dagger(x)}{\phi_o} \cdot \psi^{(q)}_{Lj}(x) + \\
& + \bar{\psi}^{(q)}_{Li}(x) \cdot \frac{\tilde{\phi}(x)}{\phi_o} \tilde{M}^{(q)}_{ij} \tilde{\psi}^{(q)}_{Rj}(x) + \bar{\tilde{\psi}}^{(q)}_{Ri}(x) \tilde{M}^{(q)\dagger}_{ij} \frac{\tilde{\phi}^\dagger(x)}{\phi_o} \cdot \psi^{(q)}_{Lj}(x) + \\
& + \theta \frac{g_s}{32\pi^2} G_{A\mu\nu}(x) \tilde{G}^{\mu\nu}_A(x)
\end{aligned}
$$

IMG by M. Di Pierro

Quark Gluon Interactions





Strong Force

- 100 times stronger than the electromagnetic force.
- The strong force is the force that holds together the nucleus of all atoms in the universe.
- Gluons are the force carriers of the strong force.
- Gluons interact with quarks in different ways according to their "color charge" which is why the study of these interactions is called quantum Chromo dynamics.

My Task

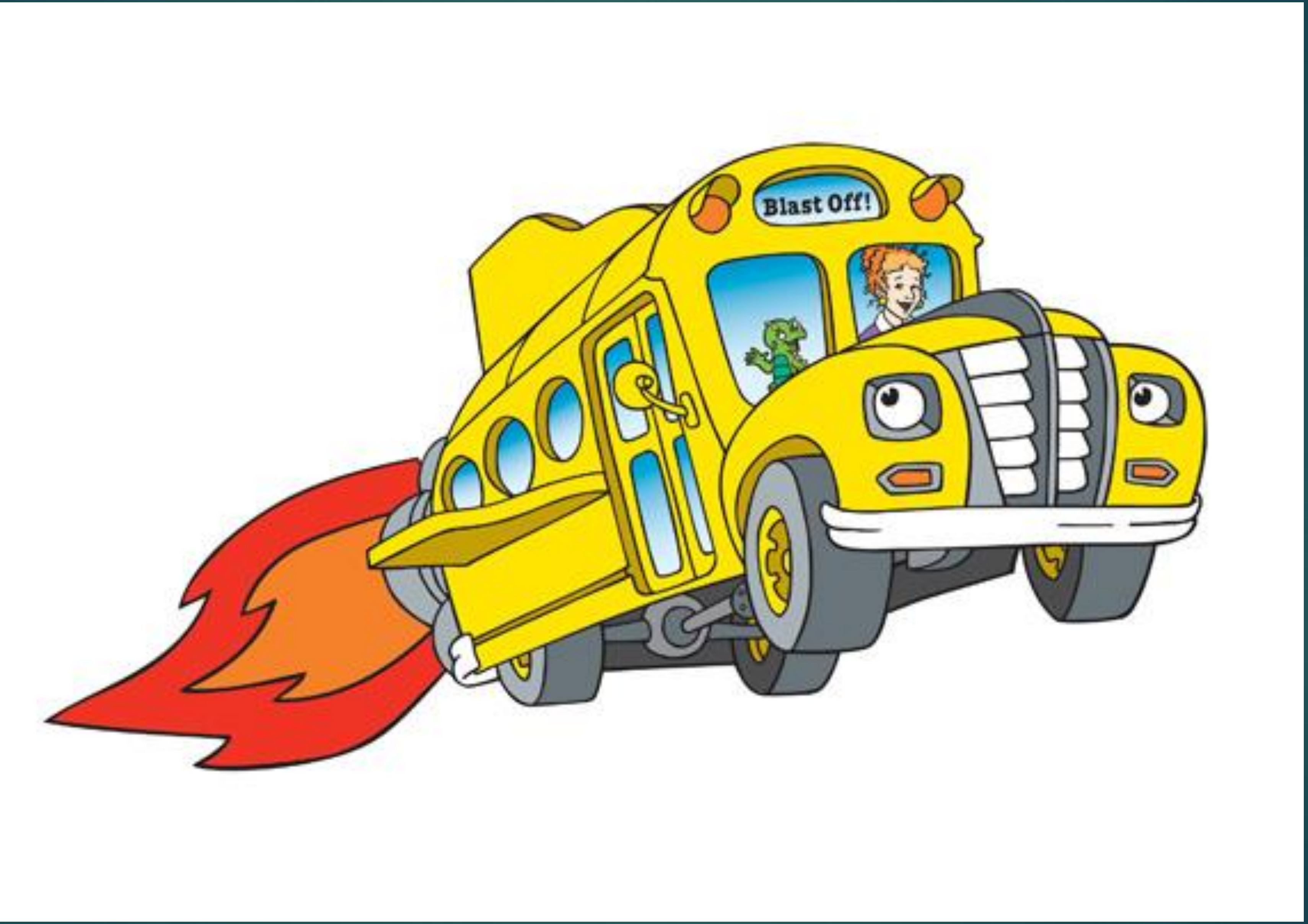
Make a network management system for the Ethernet network that presents data in a readable form that provides a quick and accessible way to monitor the efficiency of the network.

Intro to Networking

Networking is the way that data is transferred from one location to another.

Bandwidth: A measure of the amount of data that can be transferred

Latency: A measure of the speed at which the data can be transferred


Blast Off!

Networking within the LQCD

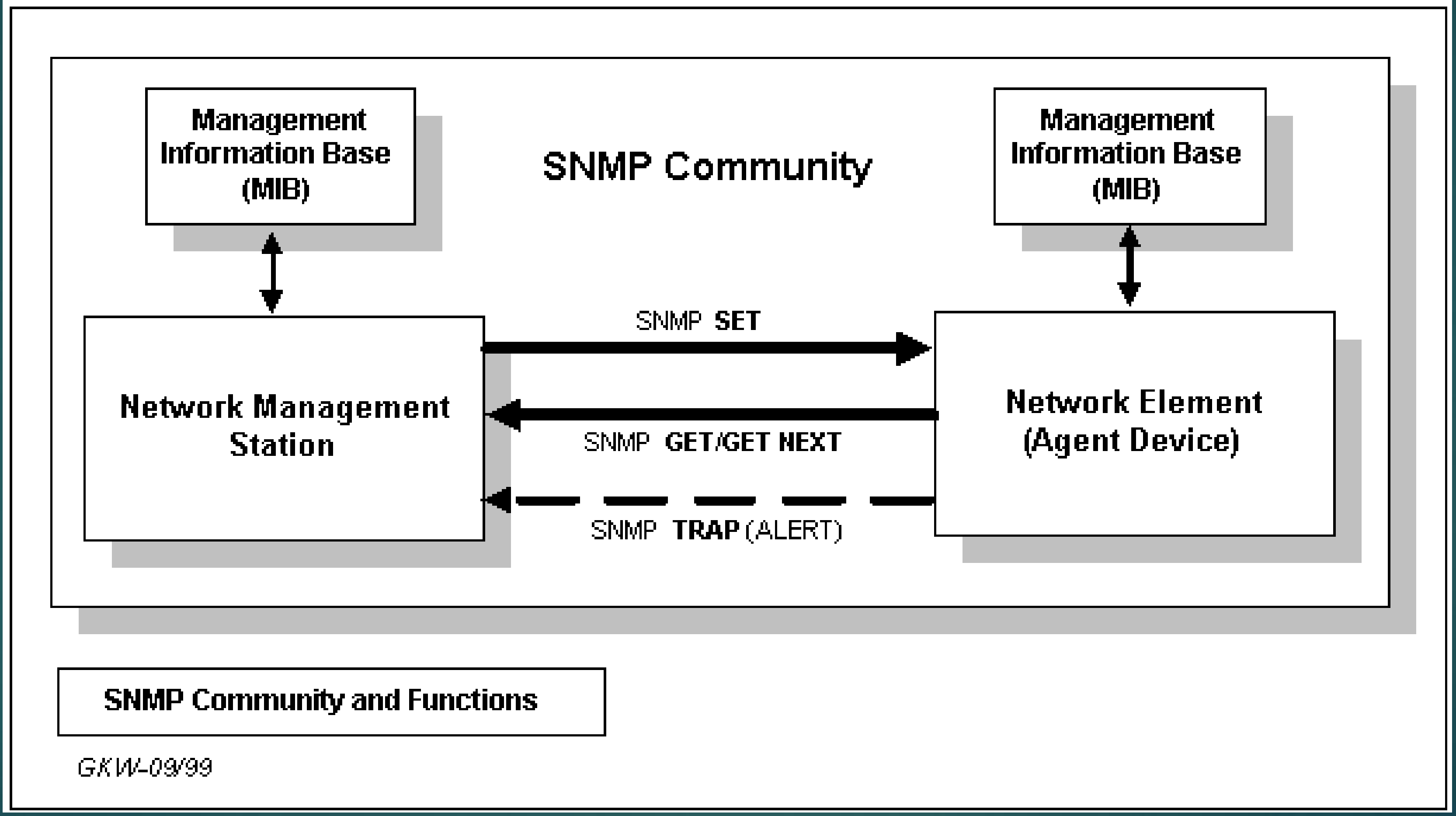
- Infiniband: This network is used to connect all of the CPU's and GPU's together in order to allow the to function as one large unit. Fermilab uses 40 Gigabit Infiniband.

- Ethernet: Is used as a service and management network and therefore is just as vital to the success of the LQCD project.

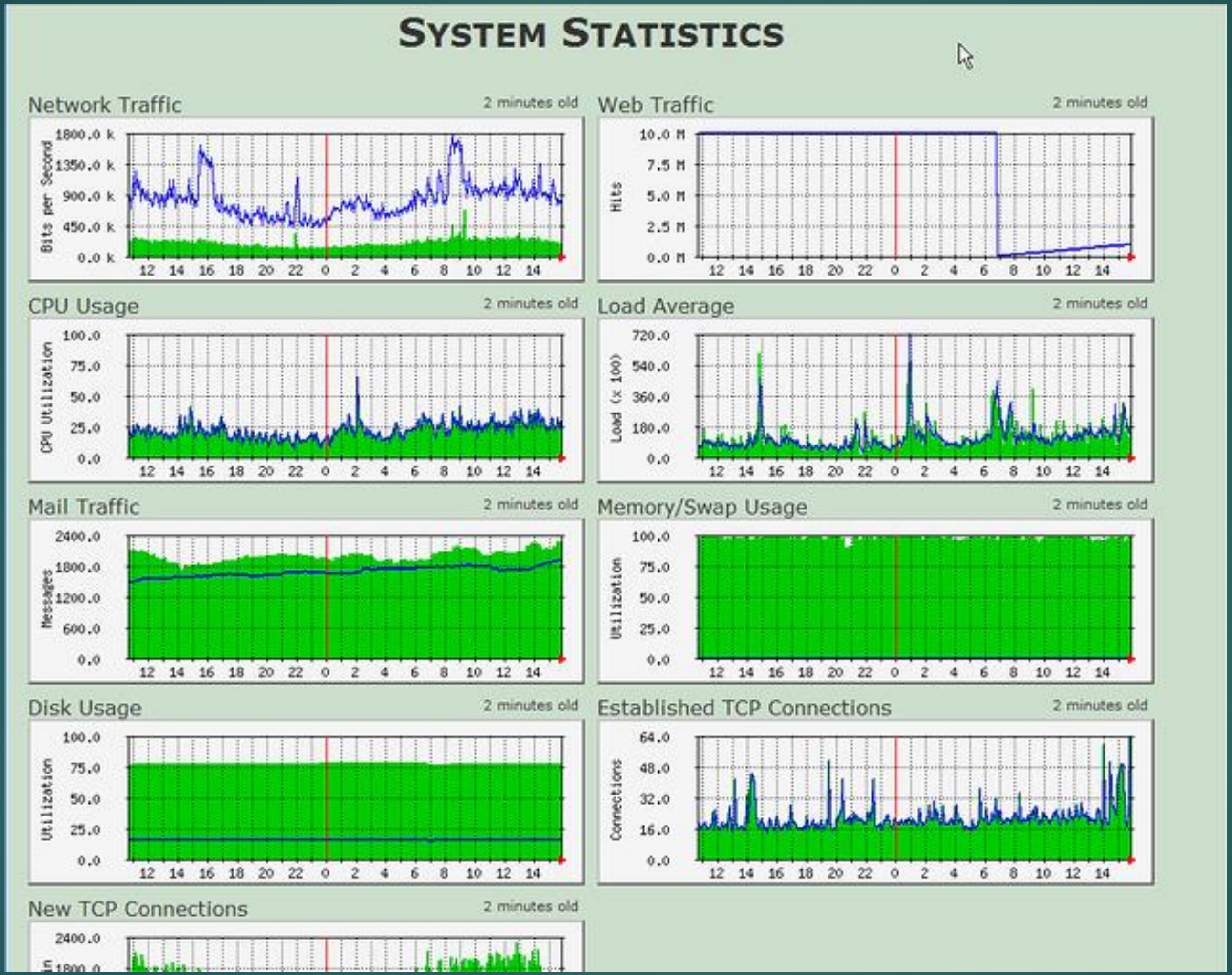
PERL

```
Perl ( is => 'so readable') {
    $you -> can (also read it);
    when (you don' => 't') {
    see it;
}
```

Simple Network Management Protocol

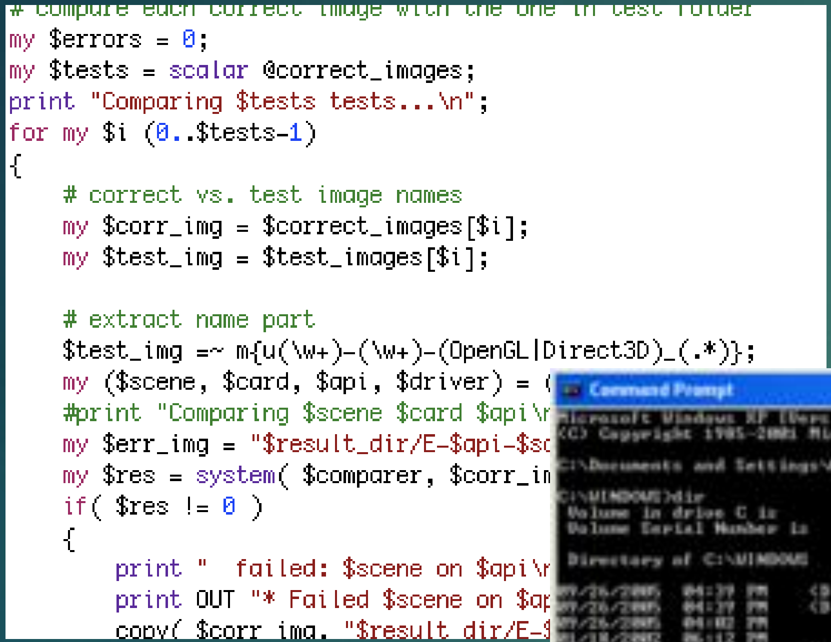


Multi Router Traffic Grapher

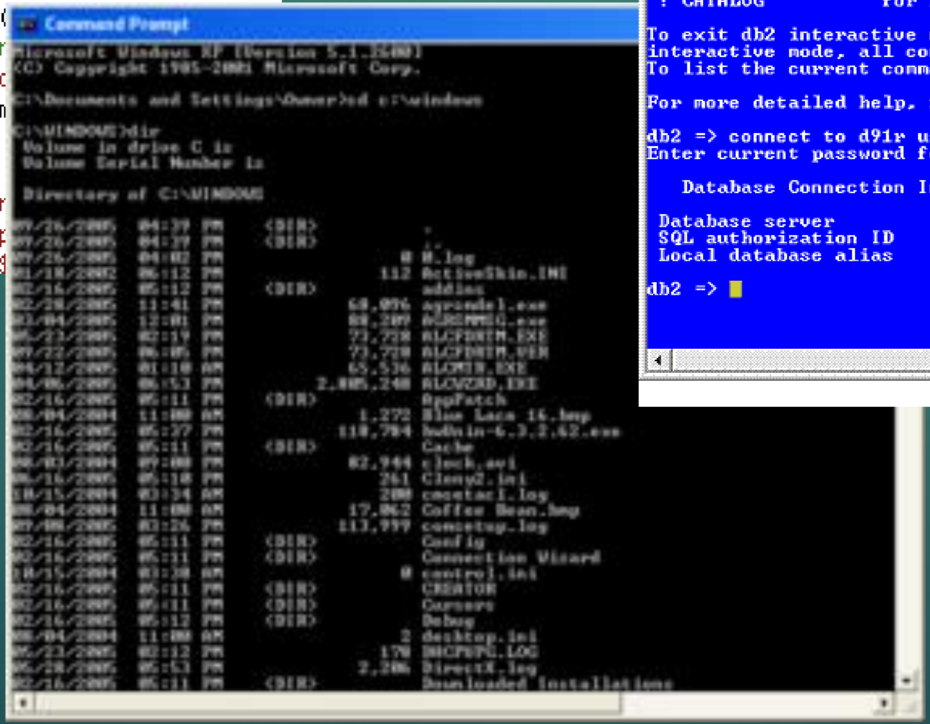


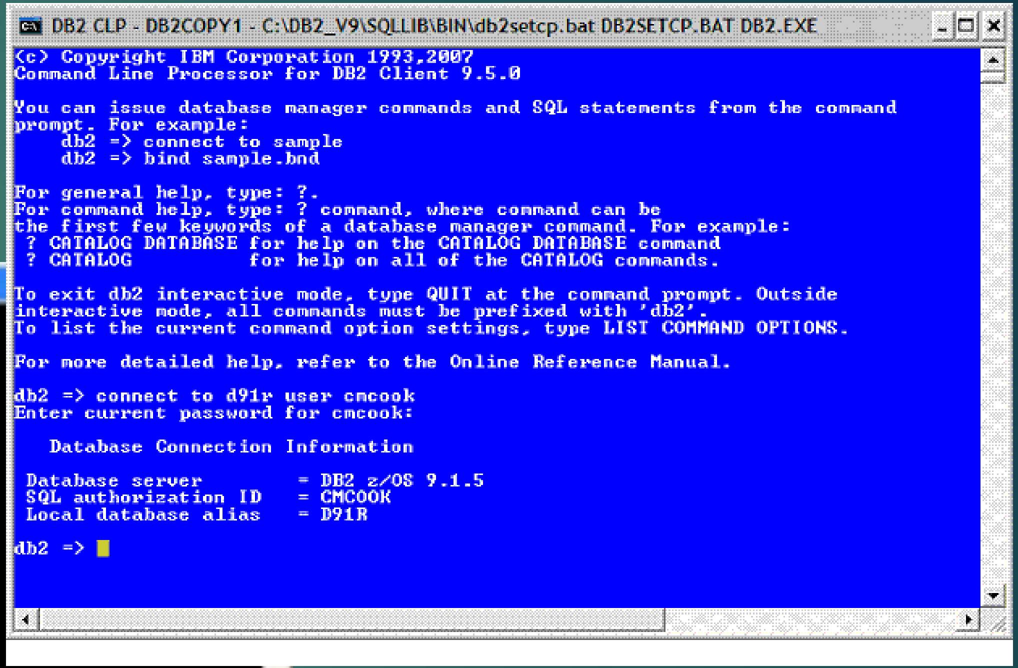
http://bc2.fnal.gov/cluster/internal/usage.html

Codes



# compare each correct image with the one in test folder
my $errors = 0;
my $tests = scalar @correct_images;
print "Comparing $tests tests...\n";
for my $i (0..$tests-1)
{
# correct vs. test image names
my $corr_img = $correct_images[$i];
my $test_img = $test_images[$i];
# extract name part
$test_img =~ m{u(\w+)-(\w+)-(OpenGL|Direct3D)_(.*)};
my ($scene, $card, $api, $driver) = (
#print "Comparing $scene $card $api\n
my $err_img = "$result_dir/E-$api-$sc
my $res = system($comparer, $corr_im
if($res != 0)
{
print " failed: $scene on $api\n
print OUT "* Failed $scene on $ap
copy($corr_img, "$result_dir/E-$





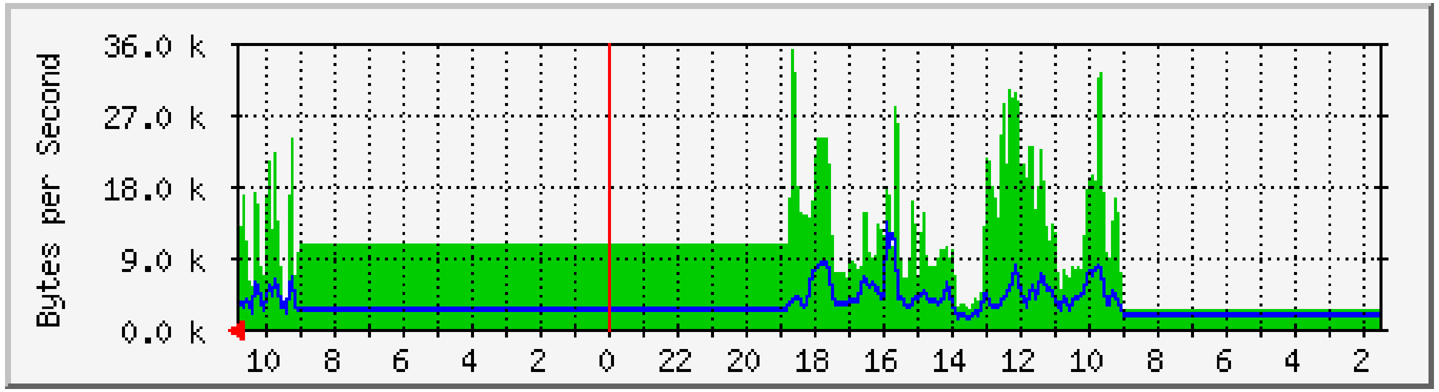
DB2 CLP - DB2COPY1 - C:\DB2_V9\SQLLIB\BIN\db2setcp.bat DB2SETCP.BAT DB2.EXE
(c) Copyright IBM Corporation 1993,2007
Command Line Processor for DB2 Client 9.5.0
You can issue database manager commands and SQL statements from the command
prompt. For example:
db2 => connect to sample
db2 => bind sample.bnd
For general help, type: ?.
For command help, type: ? command, where command can be
the first few keywords of a database manager command. For example:
? CATALOG DATABASE for help on the CATALOG DATABASE command
? CATALOG for help on all of the CATALOG commands.
To exit db2 interactive mode, type QUIT at the command prompt. Outside
interactive mode, all commands must be prefixed with 'db2'.
To list the current command option settings, type LIST COMMAND OPTIONS.
For more detailed help, refer to the Online Reference Manual.
db2 => connect to d91r user cmcook
Enter current password for cmcook:
Database Connection Information
Database server = DB2 z/OS 9.1.5
SQL authorization ID = CMCOOK
Local database alias = D91R
db2 =>

Windows versus Linux

Product

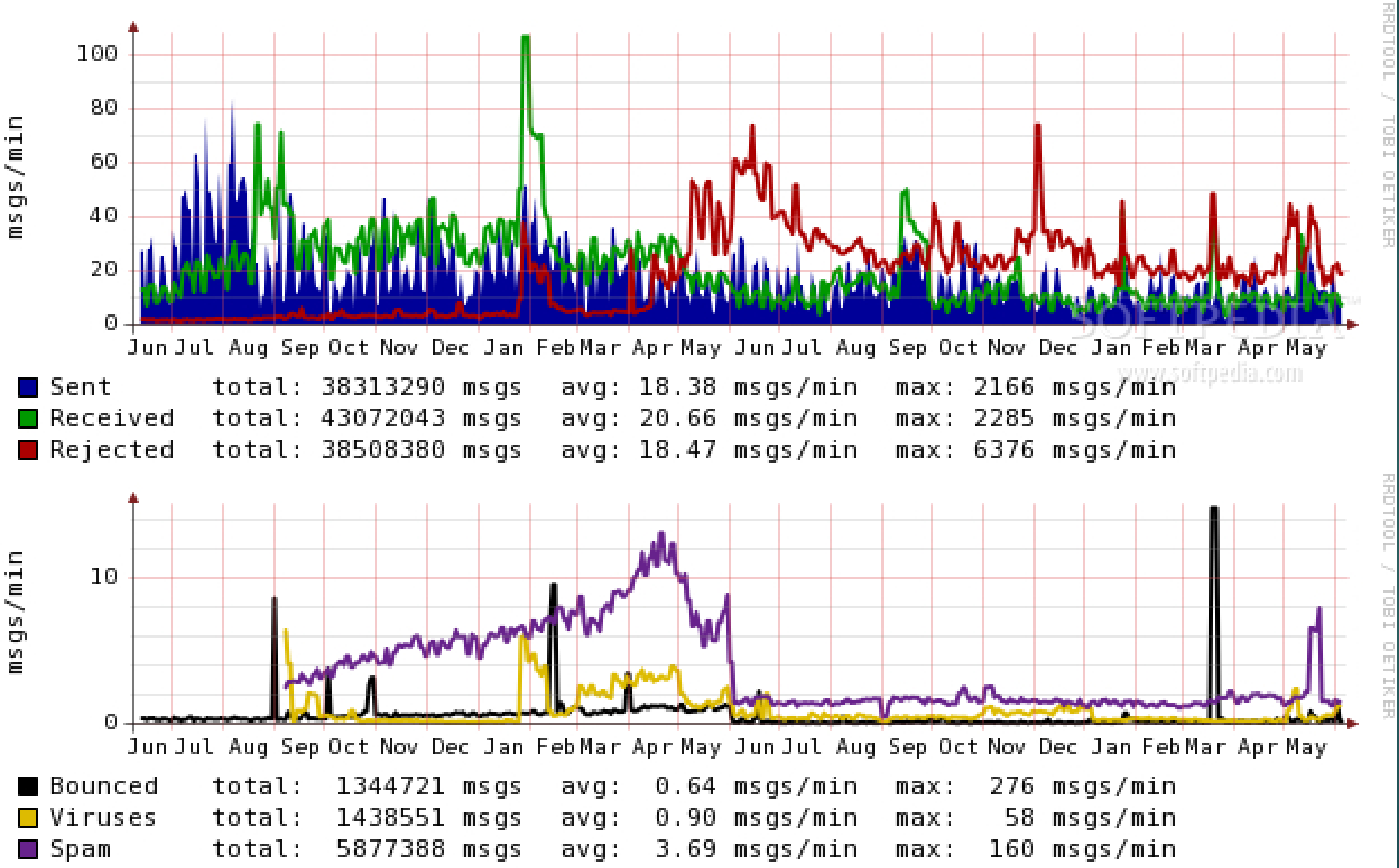
file:///C:/mrtg/bin/reports/192.168.1.10_3.html

`Daily' Graph (5 Minute Average)



	Max	Average	Current
In	35.0 kB/s (18.2%)	9794.0 B/s (5.1%)	8360.0 B/s (4.3%)
Out	13.1 kB/s (6.8%)	2769.0 B/s (1.4%)	2554.0 B/s (1.3%)

RRDTOOL


msgs/min
100
80
60
40
20
0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
RRDTOOL / TOBI OETIKER
www.softpedia.com
Sent total: 38313290 msgs avg: 18.38 msgs/min max: 2166 msgs/min
Received total: 43072043 msgs avg: 20.66 msgs/min max: 2285 msgs/min
Rejected total: 38508380 msgs avg: 18.47 msgs/min max: 6376 msgs/min
msgs/min
10
0
Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May
RRDTOOL / TOBI OETIKER
Bounced total: 1344721 msgs avg: 0.64 msgs/min max: 276 msgs/min
Viruses total: 1438551 msgs avg: 0.90 msgs/min max: 58 msgs/min
Spam total: 5877388 msgs avg: 3.69 msgs/min max: 160 msgs/min

THANK YOU