A Paper model results

The ‘paper model’ is a static model of the HLT/DAQ system used for estimating rates and processing requirements. Due to the RoI driven nature of the LVL2 trigger and the different processing sequences and associated data request patterns, a simple calculation of the quantities of interest on the basis of the LVL1 and LVL2 accept rates and average event fragment sizes is not feasible. In the past a spreadsheet has been used. Due to problems with easy modification of e.g. trigger menus and processing sequences, with the extraction of the results and with checking the correctness of the computing procedures implemented, the spreadsheet has been replaced by a program written in C++. This solved the problems mentioned as all parameters are specified in separate input files, the results to be output by the program (an array of tables in ASCII format) are chosen by parameters in an input file, and as the program source provides a clear overview of the computing procedures followed.

A.1 Input

The LVL1 trigger defines a finite number of possible RoI locations. A small region in eta-phi space corresponds to each location. For each location the rate of hits satisfying appropriate LVL1 trigger criteria is assumed to be proportional to the surface of the region associated with the location and not to depend on the coordinates in eta-phi space of the location. The sum of the rates for all possible locations is equal to the LVL1 menu RoI rate, so that the RoI rate per location can be determined. Along with information on the sizes of the regions-of-interest (see Table A-1), and the mapping of the detector on the ROLs the RoI rate for each ROL can be obtained.

Table A-1 LVL2 RoI sizes

Type of RoI	Size in η	Size in ϕ
EM	0.2	0.2
JET	0.8	0.8
TAU	0.2	0.2
MUON	~ 0.3–0.4 (depends on detector)	~ 0.1–0.4 (smallest in muon and in inner detector)

The exclusive ‘nominal’ rates for the different LVL1 trigger menu items for start-up luminosity are presented in detail in Section 13.5. The total rates are ~25 kHz at start-up luminosity and ~40 kHz at design luminosity [A-1]. These rates include a contribution of ~5 kHz for pre-scaled and calibration triggers which are not considered further in the model[1]. Estimates of the fragment sizes are presented in Table A-2. For calculating the bandwidth requirements, the fragment sizes have been increased with the sizes of headers and trailers.

1. The number of 5 kHz is an estimate. The effect of these triggers on the ROB access rates and the event building rates will be studied when a better understanding of their composition is available from the detectors. Only a small percentage will be passed through the event building stage.

Table A-2 Estimates of data fragment sizes in bytes, used as input for modelling

Sub-detector	Number of ROLs	Low luminosity (2×10^{33} cm^{-2} s^{-1})	Design luminosity (1×10^{34} cm^{-2} s^{-1})
Pixels	120	200	500
SCT	92	300	1100
TRT	232	300	1200
E.m. calorimeter (LAr Barrel and EMEC)	724	752	752
FCAL	16	752	752
Hadron calorimeter	64 (Tilecal)	752	752
	24 (HEC)	752	752
Muon precision	192	800	800
Muon trigger (RPCs and TGCs)	48	380	380
CSC	32	200	200
LVL1	56	1200 (average)	1200 (average)
Total event size, raw (Mbyte)		1.0	1.3
Total event size, with headers (Mbyte)		1.2	1.5

The LVL2 processing consists of several steps and after each step a decision is taken on whether data from other sub-detectors within the RoI should be requested for further analysis. For the four different types of RoIs the sub-detectors from which data is needed as input for the different processing steps are specified in Table A-3. The acceptance factors associated with the processing steps are also specified in the table. In combination with the RoI rates per ROL, the rates of requests for RoI data sent by the LVL2 trigger to the buffers receiving data from the ROLs, can be calculated. The final acceptance factors in Table A-3 determine the overall LVL2 accept rate and therefore the event building rate. They give rise to an event building rate of 600 Hz at the nominal LVL1 accept rate for start-up luminosity. A reliable estimate for the final LVL2 accept rate for design luminosity is not available, but for modelling purposes, 1.2 kHz at nominal LVL1 rate (and therefore 3.5 kHz at a 100 kHz LVL1 accept rate) has been chosen as working hypothesis. What is more relevant here are the modelling estimates for processing resources required for the initial ATLAS data-taking.

In order to estimate the processing resources needed for the LVL2 trigger, the algorithm execution times and the overheads for sending requests to, and receiving data from the ROS, are needed. The following numbers, assuming execution on 8 GHz dual-CPU machines, have been used in the model for each of the detectors; Muons — 6.5 ms, Calorimeters — 3.0 ms, TRT — 7.2 ms (15.3 ms for design luminosity), and SCT / Pixels — 6.7 ms (7.9 ms for design luminosity). The numbers specified include an estimation of the time needed for data preparation of 3.0 ms per sub-detector per RoI (see Chapter 14). Furthermore, for each message sent or received an overhead of 10 µs is included. The processing step resulting in a decision is assumed to take 50 µs. Merging of event fragments into a larger fragment suitable for input to the algorithms is assumed to proceed at 160 Mbyte / s. TRT data is assumed not to be analysed for muon RoIs.

Table A-3 Sub-detector data requested by different processing steps of the LVL2 trigger for the different types of RoIs and associated acceptance factors. The acceptance factors are relative to the LVL1 RoI rate.

Type of RoI	First step	Acceptance factor	Second step	Acceptance factor	Third step	Acceptance factor
EM	E.m. calorimeter	0.19 (design lum.: 0.16)	Hadron calorimeter	0.11 (design lum.: 0.16)	TRT /SCT/Pixels Threshold raise	0.012 (electron) 0.006 (photons)
JET	E.m. and hadron calorimeters	1.0			Threshold raise	0.05
TAU	E.m. and hadron calorimeters	0.20	TRT /SCT/Pixels	0.10	Threshold raise	0.033
MUON	Muon precision and trigger detectors	0.39	SCT/Pixels	0.18	E.m. and hadron calorimeters	0.10

A.2 Results

The LVL2 system and the Event Builder both send requests for data to the ROS. The rate of requests from the Event Builder for data from a single ROL, buffered in the ROS, is equal to the event building rate. The LVL2 request rate for data from a single ROL for a given sub-detector is not the same for all ROLs, as the rate depends on the mapping onto the ROLs, the possible RoI locations defined by LVL1, and on the RoI sizes. The average request rate for data from a single ROL and the largest individual request rate, calculated as outlined in the previous section, are presented in Table A-4 (for 100 kHz LVL1 accept rate). The average and largest individual volume of data requested per ROL by the LVL2 trigger and by the Event Builder for a given sub-detector are presented in Table A-5. Similar results are given in Table A-6 and Table A-7 for bus-based ROS units handling data from 12 ROLs[1]. Fragments of the same event input via different ROLs can be requested by a single message from a bus-based unit (see Chapter 5) and are concatenated and output as a single message. Data Collection and Raw Ethernet wrappers have been taken into account in the data volumes output by the ROS units.

Results for the processing resources required for the LVL2 trigger, for the number of SFIs, and for the rates per L2PU and SFI are presented in Table A-8 for a 100 kHz LVL1 rate. The number of SFIs have been obtained by requiring that the input data volume is not larger than 60 Mbyte/s. As shown in Chapter 8, this data volume can be handled when Gigabit Ethernet is used. The processing resources required for the LVL2 trigger have been calculated using the rates, processing times, and acceptance factors presented in the previous section. The number of LVL2 processors obtained assume a 77% CPU utilization. It should be emphasized that the reliability of these numbers is determined by the quality of the input parameters used. The modelling gives similar results, based on current hypotheses for input parameters, at design luminosity, for the LVL2 processing requirements and rates per L2PU. The number of SFIs increases to 87 due to the increase in event size for design luminosity.

1. For each sub-detector, groups of 12 ROLs have been formed, without regard for the partitioning of the sub-detector; for cases where the number of ROLs is not a multiple of 12, the ROS unit with less than 12 ROLs connected has not been included in the calculation of the averages.

Table A-4 LVL2 request rate (in kHz) for data from a single ROL for a 100 kHz LVL1 accept rate

Luminosity / rate	Muon precision	Muon trigger	E.m. calorimeter	Hadr. calorimeter	TRT	SCT	Pixels
Low / average	0.10	0.22	2.03	1.36	0.19	0.53	0.67
Low / maximum	0.20	0.30	7.42	1.99	0.22	0.74	0.98
Design / average	0.29	0.62	1.74	0.89	0.04	0.79	0.99
Design / maximum	0.57	0.86	6.34	1.30	0.05	1.08	1.42

Table A-5 Data volume (in Mbyte/s) requested per ROL (LVL2 data and data sent to the Event Builder) for a 100 kHz LVL1 accept rate

Luminosity / rate	Muon precision	Muon trigger	E.m. calorimeter	Hadr. calorimeter	TRT	SCT	Pixels
Low / average	2.79	1.55	4.29	3.72	1.28	1.42	1.11
Low / maximum	2.88	1.59	8.90	4.26	1.29	1.50	1.20
Design / average	3.40	1.99	4.46	3.74	4.59	5.13	2.70
Design / maximum	3.66	2.10	8.40	4.09	4.60	5.49	2.96

Table A-6 LVL2 request rate (in kHz) per ROS unit (12 ROLs) for a 100 kHz LVL1 accept rate

Luminosity / rate	Muon precision	Muon trigger	E.m. calorimeter	Hadr. calorimeter	TRT	SCT	Pixels
Low / average	0.9	1.9	12.0	9.4	1.0	3.9	5.1
Low / maximum	1.4	2.5	21.5	10.5	1.3	4.3	7.6
Design / average	2.5	5.5	10.4	6.2	0.2	5.7	7.5
Design / maximum	4.1	7.1	18.6	6.9	0.3	6.3	11.2

Table A-7 Output data volume (in Mbyte/s) per ROS unit (12 ROLs) (LVL2 data and data sent to the Event Builder) for a 100 kHz LVL1 accept rate

Luminosity / rate	Muon precision	Muon trigger	E.m. calorimeter	Hadr. calorimeter	TRT	SCT	Pixels
Low / average	34.6	19.4	54.0	46.9	16.1	18.2	14.5
Low / maximum	35.2	19.8	70.1	50.3	16.2	18.9	15.5
Design / average	42.3	25.2	56.0	46.8	56.5	64.3	34.1
Design / maximum	44.1	26.1	69.7	49.0	56.6	66.9	36.7

Table A-8 Overview of paper model results concerning L2PUs and SFIs for a 100 kHz LVL1 trigger rate at low luminosity

LVL2 farm size	495
Fragment rate in = request rate out per L2PU (kHz)	1.8
Event data volume in per L2PU (Mbyte/s)	3.2
Decision rate per L2PU (kHz)	0.20
Number of SFIs required for 60 Mbyte/s input per SFI	59
Event building rate per SFI (Hz)	51

A.3 References

A-1 S. Tapprogge, *Physics Requirements for the ATLAS Trigger,* Presentation to LHCC Meeting, March 2002, http://agenda.cern.ch/askArchive.php?base=agenda&categ=a02381&id=a02381s1t2/transparencies