National College of Ireland

National College of Ireland

MSc in Cloud Computing – Full-time – Year 1 – MSSCLOUD 1
MSc in Cloud Computing – Full-time – Year 1 – MSCCLOUD_JAN18_O

Semester One Examinations – 2018/19

Thursday 10th January 2019
10.00am – 12.00pm

Cloud Architecture

Dr Ted Scully
Dr Horacio González-Vélez

Answer ALL questions

Duration of exam: 2 hours
Attachments: None
Required: Simple/ Basic calculators only

1. Consider the standard matrix multiplication method for two square matrices as shown below:

$$\begin{pmatrix} a11 & a12 & a13 \\ a21 & a22 & a23 \\ a31 & a32 & a33 \end{pmatrix} \begin{pmatrix} b11 & b12 & b13 \\ b21 & b22 & b23 \\ b31 & b32 & b33 \end{pmatrix} =$$

$$\begin{pmatrix} a11.b11 + a12.b21 + a13.b31 & a11.b12 + a12.b22 + a13.b32 & a11.b13 + a12.b23 + a13.b33 \\ a21.b11 + a22.b21 + a23.b31 & a21.b12 + a22.b22 + a23.b32 & a21.b13 + a22.b23 + a23.b33 \\ a31.b11 + a32.b21 + a33.b31 & a31.b12 + a32.b22 + a33.b32 & a31.b13 + a32.b23 + a33.b33 \end{pmatrix}$$

Figure 1. 3x3 Matrix multiplication (credits: NCalculators.com)

Given matrices of order M (MxM), the time complexity of the sequential multiplication time can be defined as $T_1 = cM^3$ units of time, where c is a hardware-dependant constant.
Assume that a MPI parallel code requires $Tn=cM^3/n + dM^2/n$ units of time to complete on a n-node configuration, where d is a constant determined by the MPI implementation used. The second term in Tn accounts for the total message passing overhead experienced.

Answer the following questions assuming the MPI parallel code has no sequential bottleneck, is used for a matrix of order 256 ($M=256$), and executed on a 4096-node cluster ($n=4096$) with a hardware configuration with constant $c=1$. For parts a) and b) assume an implementation of MPI (e.g MPICH-2) with $d=4$.

[35 marks]

a) Using the canonical Amdahl's law, calculate the speedup of the parallel code on n nodes.

[8 marks]

b) What is the efficiency of the n-node cluster

[8 marks]

c) Assume now a MPI implementation which incorporates the MPI-3 RMA interface and has a $d=0$.

i. What is the new speedup and efficiency on n nodes?

[8 marks]

ii. Please explain the RMA concept and its relation to the d parameter, ideally using the following module reference papers:

- M Snir: Technical perspective: The future of MPI. *CACM* 61(10): 105 (2018)
- R Gerstenberger, M Besta, T Hoefler: Enabling highly scalable remote memory access programming with MPI-3 one sided. *CACM* 61(10): 106-113 (2018).

[11 marks]

2. Different industry analysts are forecasting that Apple will replace Intel for ARM-based processors in their Mac computers running macOS by 2020. Arguably, virtualisation can help Apple to ease the transition.

[Total 25 Marks]

a. Name the 5 Levels of Virtualisation

[2 mark per level (up to 10 marks)]

b. Choose one level from the five above which can enable macOS applications in this transition, justifying your choice via its possible advantage(s) and disadvantage(s).

[15 marks for chosen level and justification]

3. For the OpenStack private cloud shown below, consider the System Availability (A) of in terms of MTTF (Mean Time to Failure), MTTR (Mean Time to Repair) and RMT (Regular Maintenance Time).

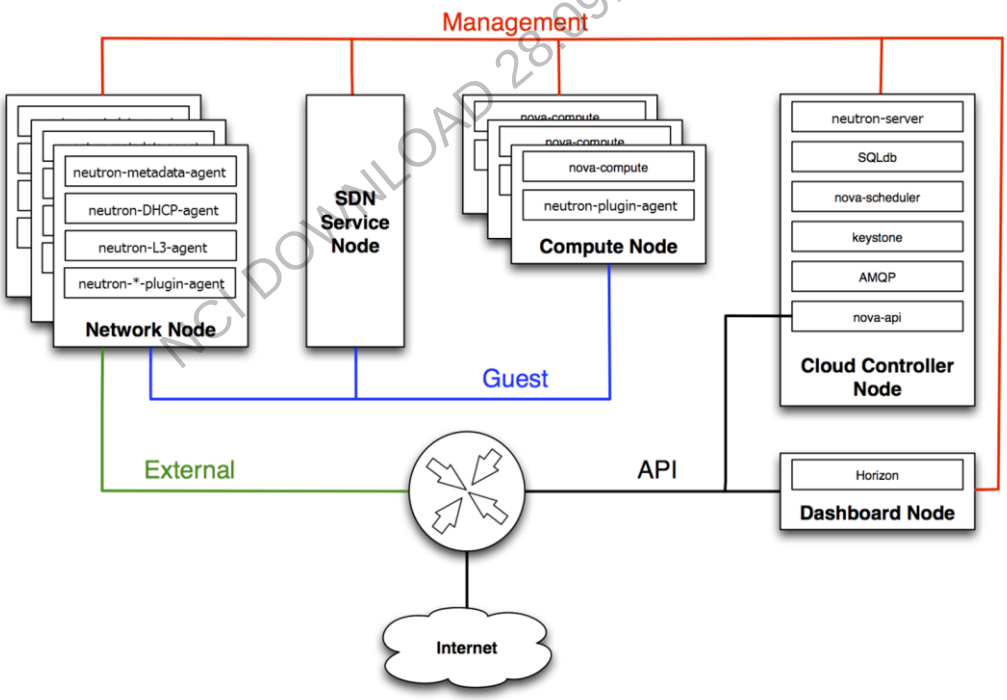

Figure 2. Standard OpenStack architecture (Credits: OpenStack.org)

Assume this OpenStack private cloud has:

- An end-to-end two-nines SLA i.e. the system availability is considered from any Internet client up to any service/node (A=99%);
- MTTF of one year; and
- MTTR of 48 hours.

What is the value of RMT (hours per month) the OpenStack cloud administrator should schedule to comply with the SLA?

[Total 20 Marks]

4. EC2 and Lambda are two distinct compute services offered by the AWS public cloud infrastructure. Briefly describe both offering and critically compare them, particularly in terms of elasticity, providing an application example for each one.

[5 marks per each description and 10 marks for critical comparison]

[20 marks]