The social distancing obligation, and partial/full lockdown conditions due to the Covid-19 pandemic have shifted the in-person teaching and learning to online classes for most of the students around the globe. There are four important components of online teaching:

1. Provision of the teaching material (electronic files, lecture notes, etc.)
2. Availability of courseware including different educational training technologies (interactive presentations, online network simulators etc.) and references (i.e., online books, assisted teaching websites etc.)
3. Accessibility of digital resources (videos lectures, virtual simulation experiments, etc.)
4. Online assessments including quizzes, exams, and the evaluations of lab tasks etc.

Amongst these components, the most challenging to implement is the assessment of tasks for some particular modules related to the domain of Computer Science especially for Computer Networks both at the undergraduate and graduate level. Assessment of computer network concepts easily accomplished via traditional exam methods (i.e., closed/open book exam) conducted at the exam center. However, for the online assessments, it is very difficult to assess the efforts of a student fairly because some students might take some help from the solved case-studies available on the Internet. Despite the best efforts of the teacher, this unethical practice by students is hard to monitor and curb. Similar is the case with lab contents, where the lab tasks at the undergraduate level include either the design of some networking scenarios, or simulation of an implemented/modified solution in network simulators. In these scenarios, even the virtual monitoring of all students is almost impossible if the class size is very large. This is perhaps the most challenging task that the computer network community needs to address by devising some standardized ways to assess the theoretical and practical tasks of computer networks.

In this whitepaper, we have discussed a possibility of the deployment of intelligent script at web server to conduct and evaluate online exam of computer networks while taken into account associated essential assessment themes. Therefore, at first, we have identified the types
of assessment themes of computer network exams and secondly, we have suggested ways for individual and group task evaluation.

There can be four types of assessment themes as shown in Figure 1 that are required to be evaluated in a final exam of computer networks including:

(a) Networking Fundamentals (correct interpretation of basic network concepts e.g., evaluation of network delay types, functionality and working details associated with different layers and protocols of standard network architectures (OSI Model and TCP/IP Protocol Stack), analytical questions related to performance measures, etc.)

(b) Network Planning (e.g., case-studies concerning the understanding of IP addressing, subnetting, supernetting, etc.)

(c) Evaluation of network protocol algorithms (e.g., MAC algorithms, Routing algorithms, etc.)

(d) Network Design and Configuration (e.g., selection and connectivity of hardware components and software configurations including server configuration, router configuration, DHCP configuration, DNS configuration, etc.)

![Figure 1: Main Assessment Themes of Computer Network Exam](image)

Below, we have discussed the suggestions or recommendations to evaluate all these assessment themes in an online exam.

The evaluation of theme (a), which is theoretical in nature, can be accomplished for individual assessment through:

- constructing a database of questions regarding particular topics related to fundamental concepts of networking
- implementation of intelligent script at web server to perform randomization in different ways; for example,
  - shuffling and assigning of different questions to different students at each time slot as shown in Figure 2.
  - assigning of same question with variation in customized parameters for analytical/numerical questions as shown in Figure 3.

Figure 2: Assigning of Different Questions (Q₂ and Q₃) to Different Students

Figure 3: Assigning of Same Numerical Question (Q₁) with Different Parameter Values to Different Students
For the assessment of theme (b), script implementation at application server should be intelligent enough to generate diverse case-studies regarding different networking scenarios for the evaluation of concepts of IP addressing, IP subnetting, supernetting, and planning of Local Area Networks (LANs) while taking into account multiple blocks within a campus or in an organization. These case-studies that can be randomly assigned to students, who are then required to answer these questions in a real-time online test/exam provision while they attempt to solve the case study as shown in Figure 4.

![Figure 4: Assigning of Same Case study (CS1) with Different IP Addressing and Subnetting Parameters to Different Students](image)

The assessment of theme (c) is based on the capability of intelligent script at server to construct distinct topologies for same algorithm evaluation by different students at the same time as shown in Figure 5.

![Image](image)

The assessment of theme (d), which is practical in nature, can be accomplished for evaluating of student ‘collaboration’ on assigned tasks into ‘peer to peer learning’. Instead of setting individual tasks, it is time to engage the students in collaborative activities through setting team-based tasks. For this, sever-side script should be able to assign distinct network scenarios to check knowledge of students related to the connectivity of networking hardware components and software configurations (including web server configuration, router configuration, DHCP
configuration, DNS configuration etc.) to establish small-scale network prototype for any institution or organization as shown in Figure 6.

Figure 5: Assigning of Same Question (Q₄) with Different Topologies to Different Students

Figure 6: Assigning Different Network Topologies to Implement in Packet Tracer
In short, online student assessments are challenging and require special attention in order to not only assess the students fairly, but also restore the students’ confidence in the assessment process. This paper presents few initial thoughts on improving the online assessment process through various strategies aiming at different assessment themes. The proposed methodologies are presented for computer networks course; however, they should be applicable to most of the computer science and engineering courses. We believe that the use of artificial intelligence and machine learning could be incorporated to create the assessment tasks more efficiently that could make basis of fair assessment of individual as well as team performances.