



## CNIT 481 Software Defined Networks

### Course Information

- **Course number and title:** CNIT 48101-21 Software Defined Networks
- **CRN:** 25003 (Lecture) and 25002 (Lab)
- **Meeting day(s) and time(s).**

<u>Semester</u>	<u>Meeting Type</u>	<u>Days</u>	<u>Time</u>	<u>Location</u>
Spring 2022	Lecture 01	TR	8:30-9:20am	KNOY B029
	Laboratory 01	M	1:30-3:20pm	KNOY 206
	EXAM 1	Feb 24 <sup>th</sup>	8:30-9:20am	KNOY B029 or alternate
	EXAM 2	Apr 14 <sup>th</sup>	8:30-9:20am	KONY B029 or alternate

- **Instructional Modality:** Face-to-Face, assigned location and assigned time on campus.
- **Course credit hours:** 03
- **Prerequisites:** CNIT 34500

### Instructor Contact Information

- **Name:** Deepak Nadig
- **Office:** KNOY 276
- **Phone:** (765) 496-0873
- **Email:** nadig@purdue.edu
- **Office Hours:** TR 9:30-10:30am, or by appointment (in-person or virtual).

### Course Description

Software defined networking (SDN) is a rapidly emerging networking paradigm that facilitates the separation of control and data plane. The purpose of this course is to provide students the knowledge and skills necessary to use develop, manage, and secure software defined networks (SDN). The course will have the following elements, including software defined network (SDN) architectures/protocols, network functions virtualization (NFV), network virtualization technologies, and an introduction to programmable data planes. The course will use open-source software to create, deploy, manage, and secure SDNs. Numerous industry SDN solutions have emerged from companies such as Google, IBM, Facebook, AT&T, Cisco, Intel among others. SDN enables innovation, openness and helps reduce CAPEX and OPEX. The course covers the SDN foundations and building blocks; control plane abstractions; SDN controller design and data consistency guarantees; SDN scalability, security, and reliability. The course will also introduce new SDN-enabled networking capabilities, including traffic engineering, automation/orchestration, network virtualization, and verification/troubleshooting for both cloud-native and carrier networks.

## Learning Resources, Technology & Texts

- *Required and Additional Readings.*

The readings for the course will be from online textbooks (Safari Online) and research papers which should be accessible at no cost to Purdue students. If you would like to purchase the textbook, you might be able to pick up a paper copy through an online bookseller.

Links to both required and additional readings will be posted on the *Readings* link on Brightspace learning management system.
- *Software/web resources.*
  - 1) Word Processor (i.e., MS Word), remember that [MS Office is free for all students](#).
  - 2) Mininet, <http://mininet.org/>
  - 3) P4, <https://p4.org/>
  - 4) Scapy, <https://scapy.net/>
  - 5) eBPF, <https://ebpf.io/>
  - 6) ONOS, <https://opennetworking.org/onos/>
  - 7) Ryu, <https://ryu-sdn.org/>
  - 8) NetFPGA, <https://netfpga.org/>
  - 9) Oracle VirtualBox, <https://www.virtualbox.org/>
  - 10) Vagrant, <https://www.vagrantup.com/>
  - 11) OpenStack, <https://www.openstack.org/>
  - 12) Open Networking Foundation, <https://opennetworking.org/>
  - 13) Cloud Native Computing Foundation, <https://www.cncf.io/>
  - 14) Linux Foundation, <https://www.linuxfoundation.org/>
  - 15) Overleaf, <https://www.overleaf.com> (Overleaf pro accounts are available to Purdue Students with the Purdue email).
- Visit [Ask a Librarian](#) to connect with helpful resources and services provided by the Purdue Libraries and School of Information Studies for course assignments and projects.
- *Brightspace learning management system (LMS)*

Access the course via Purdue's Brightspace learning management system. Begin with the Start Here tab, which describes how the course Brightspace is organized. It is strongly suggested that you explore and become familiar not only with the site navigation but with content and resources available for this course. See the Student Services widget on the campus homepage for resources such as Technology Help, Academic Help, Campus Resources, and Protect Purdue.

## Learning Outcomes

By the end of the course, you will be able to:

- Describe how SDN solves various network issues and implement SDN use cases for network management, monitoring and security
- Understand different SDN south-bound protocols, abstractions, APIs, and features
- Understand and implement programmable network solutions using OpenFlow, REST, Netconf
- Identify, critique, and demonstrate various SDN implementation and migration strategies
- Effectively develop and deploy SDN applications and manage SDN controllers
- List the requirements of a secure SDN network for different domains
- Understand and implement Protocol Independent Forwarding (PIF) and P4, and other packet forwarding innovations beyond OpenFlow

## Assignments

Your learning will be assessed through a combination of participation, quizzes, exams, and a final project spread throughout the academic period. Details on these assignments and exams, including a schedule of due dates,

rubrics to guide evaluation, and guidelines on discussion participation and evaluation will be posted on the course website.

<b>Assessment Mechanism</b>	<b>Points</b>	<b>Weight</b>
Participation	50	5%
Quizzes	100	10%
Exams	250	25%
Papers	300	30%
Project	300	30%

- Participation (50 points; ongoing). Participation points can be earned each week through a variety of small assignments or documentation which can be completed remotely and uploaded to Brightspace. Please read the feedback that I provide for ways to enhance this grade going forward and consult with me if you find yourself struggling to participate so we can develop appropriate strategies together.
- Quizzes (100 points; ongoing). Quizzes will be unannounced. The lowest quiz score will be dropped from the student's final score at the end of the semester.
- Exams (250 points; TBD). Two exams will be conducted, and the details will be available in Brightspace, including a sample exam. It will consist of a mix of multiple-choice, short answer, and/or essay questions.
- Papers (300 points; TBD). You will work one or two term papers on special topics of interest. The paper(s) will include a detailed discussion on the topic of interest and an in-class presentation.
- Project (300 points; TBD). Details about this project, including the topics, presentation and final report will be available by Feb 1.

## Grading Scale

In this class, grades reflect the sum of your achievement throughout the semester. You will accumulate points as described in the assignments portion above, with each assignment graded according to a rubric. At the end of the semester, final grades will be calculated by adding the total points earned and translating those numbers (out of 1000) into the following letters. *NOTE: Percentages will be rounded-off to the nearest tenth. E.g., a score of 93.3% will be rounded to 93%, a score of 93.5% or higher will be rounded to 94%.*

- A+: 97 – 100%
- A: 94 – 96%
- A-: 90 – 93%
- B+: 87 – 89%
- B: 84 – 86%
- B-: 80 – 83%
- C+: 77 – 79%
- C: 74 – 76%
- C-: 70 – 73%
- D+: 67 – 69%
- D: 64 – 66%
- D-: 60 – 63%
- F: 59% or below

## Attendance Policy

This course follows Purdue's academic regulations regarding attendance, which states that students are expected to be present for every meeting of the classes in which they are enrolled. Attendance will be taken at the beginning of each class and lateness will be noted. When conflicts or absences can be anticipated, such as

for many University-sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible. For unanticipated or emergency absences when advance notification to the instructor is not possible, the student should contact the instructor as soon as possible by email or phone. When the student is unable to make direct contact with the instructor and is unable to leave word with the instructor's department because of circumstances beyond the student's control, and in cases falling under excused absence regulations, the student or the student's representative should contact or go to the [Office of the Dean of Students website](#) to complete appropriate forms for instructor notification. Under academic regulations, excused absences may be granted for cases of grief/bereavement, military service, jury duty, and parenting leave. For details, see the [Academic Regulations & Student Conduct section](#) of the University Catalog website.

Guidance on class attendance related to COVID-19 are outlined in the [Protect Purdue Pledge for Fall 2021](#) on the Protect Purdue website.

### Academic Guidance in the Event a Student is Quarantined/Isolated

If you must miss class at any point in time during the semester, please reach out to me via email so that we can communicate about how you can maintain your academic progress. If you find yourself too sick to progress in the course, notify your adviser and notify me via email or Brightspace. We will make arrangements based on your particular situation. Please note that, according to [Details for Students on Normal Operations for Fall 2021](#) announced on the Protect Purdue website, "individuals who test positive for COVID-19 are not guaranteed remote access to all course activities, materials, and assignments."

### Course Schedule (Subject to change\*)

Week	Topic	Week	Topic
Week 1	SDN Foundations – I	Week 9	Data Plane Architectures – I
Week 2	SDN Foundations – II	Week 10	Spring Break
Week 3	Controller Architectures	Week 11	Data Plane Architectures – II
Week 4	Control and Data Plane Abstractions	Week 12	Security and Fault Tolerance
Week 5	SDN Applications	Week 13	Practical Challenges
Week 6	Debugging, MiddleBoxes and Endhosts	Week 14	Advanced Topics
Week 7	Network Virtualization	Week 15	Advanced Topics
Week 8	Next-generation Network Protocols	Week 16	Final Project Presentation

\* Schedule and assignments are subject to change. Any changes will be posted on the learning management system.

Student must consult the Purdue [Academic Calendar](#) and key University dates for the Spring 2021.

### Classroom Guidance Regarding Protect Purdue

Any student who has substantial reason to believe that another person is threatening the safety of others by not complying with Protect Purdue protocols is encouraged to report the behavior to and discuss the next steps with their instructor. Students also have the option of reporting the behavior to the [Office of the Student Rights and Responsibilities](#). See also [Purdue University Bill of Student Rights](#) and the Violent Behavior Policy under University Resources in Brightspace.

## Academic Integrity

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing [integrity@purdue.edu](mailto:integrity@purdue.edu) or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies.

- 1) Any form of cheating on any examination in the course may result in an “F” grade for the course, and the case will be forwarded to the Office of the Dean of Students for appropriate disciplinary action.
- 2) Any form of cheating on a homework or project submission will result in both a zero score for the assignment, and a one-letter grade penalty in the course. Also, the case will be forwarded to the Office of the Dean of Students for appropriate disciplinary action.
- 3) Any form of cheating on a quiz will result in a zero score for that quiz, and the case will be forwarded to the Office of the Dean of Students for appropriate disciplinary action.
- 4) Cheating, or helping another student to cheat, are considered equal cases of academic dishonesty and will be dealt with as noted above.
- 5) Giving another student access to your computer account, or negligently permitting another student to access your computer account constitutes cheating on your part if that other student copies any files that become implicated in a cheating case. Protect your account at all times as if your academic career depends on it!

## Nondiscrimination Statement

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. A hyperlink to Purdue’s full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.

## Accessibility

Purdue University is committed to making learning experiences accessible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: [drc@purdue.edu](mailto:drc@purdue.edu) or by phone: 765-494-1247.

## Mental Health/Wellness Statement

**If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try [WellTrack](#).** Sign in and find information and tools at your fingertips, available to you at any time.

**If you need support and information about options and resources,** please contact or see the [Office of the Dean of Students](#). Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.

**If you find yourself struggling to find a healthy balance between academics, social life, stress, etc.** sign up for free one-on-one virtual or in-person sessions with a [Purdue Wellness Coach at RecWell](#). Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at [evans240@purdue.edu](mailto:evans240@purdue.edu).

**If you're struggling and need mental health services:** Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact [Counseling and Psychological Services \(CAPS\)](#) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office on the second floor of the Purdue University Student Health Center (PUSH) during business hours.

CAPS also offers resources specific to COVID-19 on its [website](#). Topics range from “Adjusting to the New Normal” to “How to Talk with Professors about Personal Matters.”

## Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global crisis as it related to COVID-19, students may submit requests for emergency assistance from the [Critical Needs Fund](#)

## Emergency Preparation

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

## Incompletes

A grade of incomplete (I) will be given only in unusual circumstances. To receive an “I” grade, a written request must be submitted prior to [date] and approved by the instructor. The request must describe the circumstances, along with a proposed timeline for completing the course work. Submitting a request does not ensure that an incomplete grade will be granted. If granted, you will be required to fill out and sign an “Incomplete Contract” form that will be turned in with the course grades. Any requests made after the course is completed will not be considered for an incomplete grade.

## Course Logistics

- All assignments are due by 11:59 p.m. ET on the due date listed in the course schedule.
- All assignments must use the **PDF** format for reports and papers, and **.tar.xz** format for multiple artifacts or code submissions.
- An assignment file should be appended by your username, such as “*assignment1-nadig.pdf*,” or “*assignment1-nadig.tar.xz*.” This will make it easier for me to manage assignment files.

## Diversity & Inclusion

1. In our discussions, structured and unstructured, we will explore a variety of challenging issues, which can help us enhance our understanding of different experiences and perspectives. This can be challenging, but in overcoming these challenges we find the greatest rewards. While we will design guidelines as a group, everyone should remember the following:
  - We are all in the process of learning about others and their experiences. Please speak with me, anonymously if needed, if something has made you uncomfortable.

- Intention and impact are not always aligned, and we should respect the impact something may have on someone even if it was not the speaker's intention.
  - We all come to the class with a variety of experiences and a range of expertise, we should respect these in others while critically examining them in ourselves.”
2. This course, as with every course offered at Purdue, plays a part in creating and sustaining a welcoming campus where all students can excel. There are many initiatives in CIT department and supported by the university focused on this goal, and this course is designed to take advantage of those resources. Learning experiences and assignments address diversity and inclusion, not because they are “topics,” but because they are necessary to prepare students to be successful in a diverse, global environment.
  3. We strive for equity, providing equal access and opportunity, and working to maximize student potential. This requires both instructor and students to identify and remove barriers that may prevent someone from full access or full participation. You can help by:
    - Contacting me, anonymously if needed, if you see a potential barrier for someone or yourself in participating fully in the class. This might be a physical barrier such as access to technology or a personal situation.
    - Suggesting ways in which members of our class can support each other. Virtual study groups and discussion boards are examples, but I encourage you to be creative in your ideas.
    - Getting to know each other as contributing members of our learning community. Everyone has something to contribute, and while I designed the course to take advantage of the wealth of knowledge, expertise, and experience we bring together, I cannot do it well without your participation. There are many opportunities built into this course for this type of work. It is important we do it together.