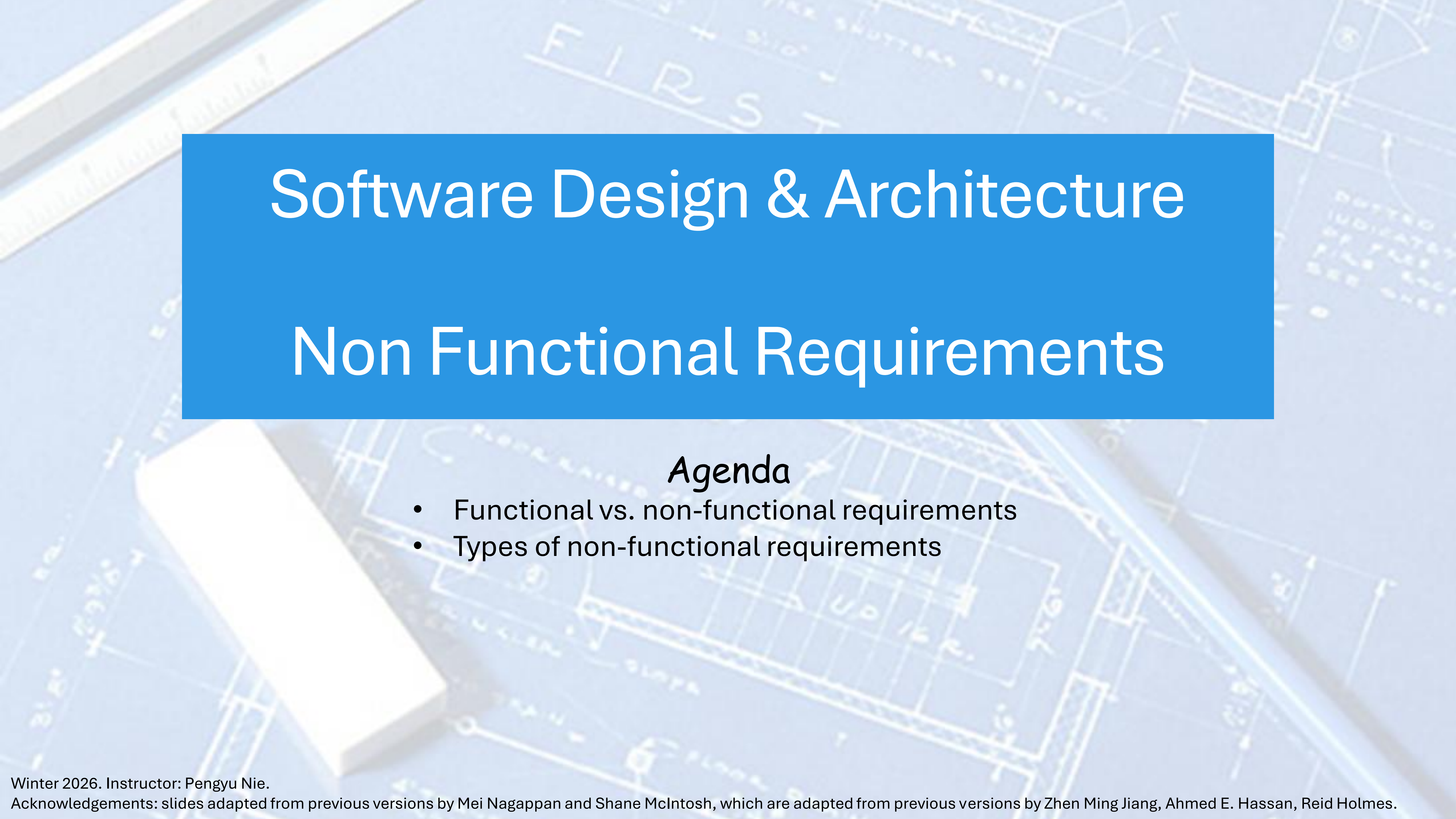


Software Design & Architecture

Non Functional Requirements

Agenda

- Functional vs. non-functional requirements
- Types of non-functional requirements

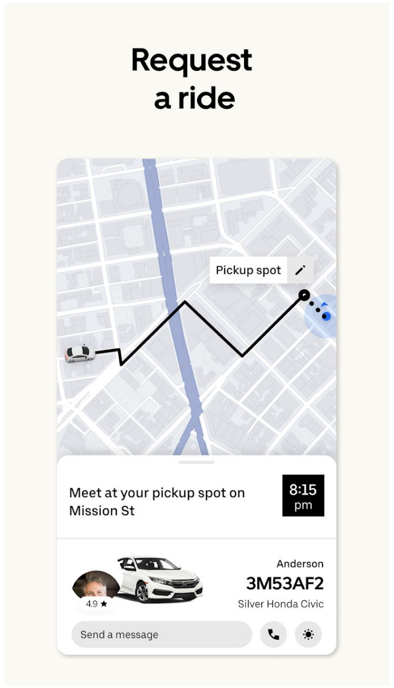
Winter 2026. Instructor: Pengyu Nie.
Acknowledgements: slides adapted from previous versions by Mei Nagappan and Shane McIntosh, which are adapted from previous versions by Zhen Ming Jiang, Ahmed E. Hassan, Reid Holmes.

Non-Functional Requirements

- Functional requirements (features)
  - what the system is supposed to do
- Non-functional requirements (constraints)
  - what the system is supposed to be

The app shall allow users to request a ride

The app shall display the driver's location



Usability: A first-time user shall be able to request a ride in ≤ 3 steps

Efficiency: Driver location shall refresh at least every 2 seconds

FR vs NFR

- Products are sold based on their functional requirements
  - ride sharing, messaging, video streaming; cell phone, car, tent
- However, non-functional requirements play a critical role in perception
  - “This app keeps crashing” (reliability)
  - “It’s too slow” (efficiency)
  - “It doesn’t work with …” (compatibility)
- Non-functional requirements are differentiators for similar products

Uber vs lyft

vs

How to write requirements?

- Ask stakeholders / consider the questions they may ask
- Customers: features, user experience
- Management: are we on schedule?
- Developers: who is responsible for implementing what?
- Sales: can we claim it can do this task?
- QA: what teams do we talk to about defects?
- DevOps: where should this component be deployed?
- Support: which QA team signed off on this?
- Maintenance: how can we add this feature?

Types of NFRs

user experience

- Usability
- Accessibility

performance

- Efficiency
- Scalability

continuity of service

- Availability
- Reliability
- Robustness
- Fault-tolerance
- Survivability

harm prevention

- Security
- Privacy
- Safety

ecosystem

- Portability
- Heterogeneity

development

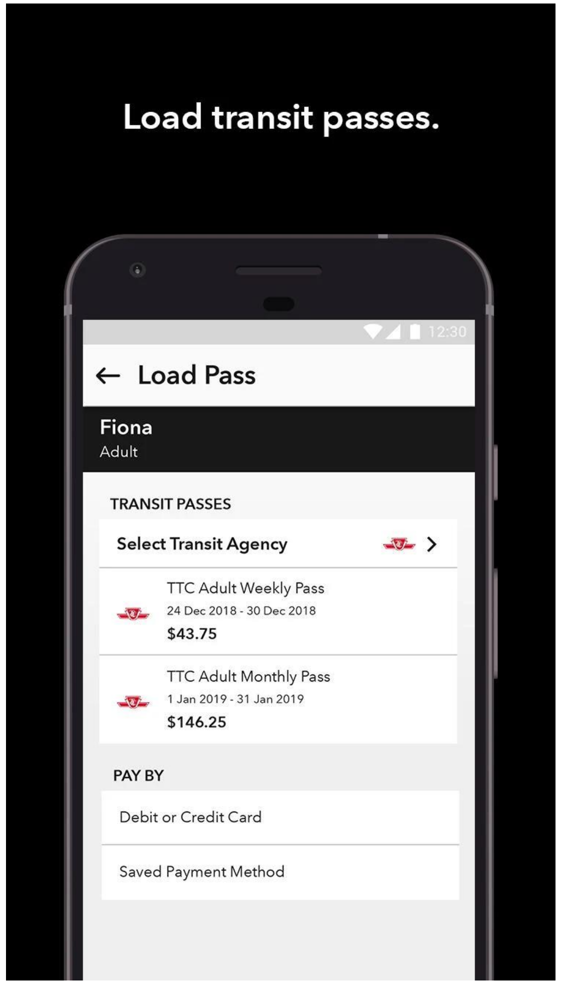
- Evovability
- Readability
- Complexity

NFRs related to User Experience

- Usability: How intuitive the user interface of the system is
  - e.g., easily navigate through different features, including X Y Z
- Accessibility: The degree to which a product, device, service, or environment is available to as many people as possible
  - e.g., is compatible with screen reader and uses alt text for all images

NFRs related to User Experience - Example

- Transit ticketing app
- The app shall allow riders to plan trips and buy tickets. Riders may be in a hurry, in bright sunlight, with spotty connectivity, and some riders use assistive technologies.
- Usability: A first-time user can buy a single-ride ticket in at most 4 screens, with no account creation required.
- Accessibility: The app supports screen readers, namely all controls have labels, and there is no "color-only" meaning.



TTC Adult Weekly Pass
24 Dec 2018 - 30 Dec 2018
$43.75

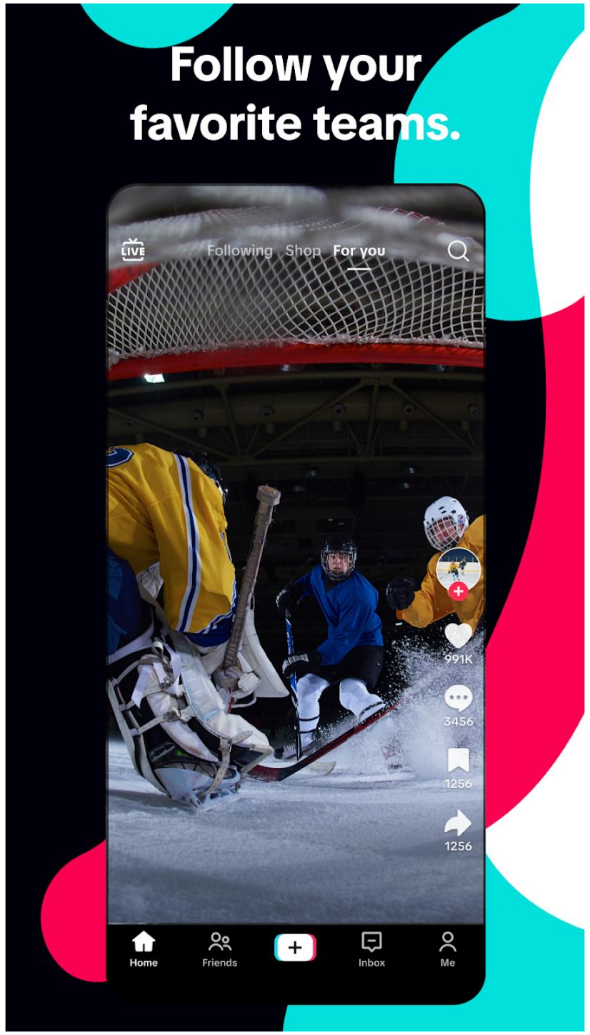
TTC Adult Monthly Pass
1 Jan 2019 - 31 Jan 2019
$146.25

NFRs related to Performance

- Efficiency: Ability to meet performance requirements
  - e.g., completes operation Y in X seconds
- Scalability: Capability of a system to be adapted to meet new size/scope requirements
  - e.g., can automatically scale resources to support at most X users

NFRs related to Performance - Example

- Short video app
- The app shall allow users to create and upload short videos.
  The home feed shall recommend hot/interesting videos.
  A major event is happening (lots of live users).
- Efficiency (latency): Home feed shall load within 1s, after which "time-to-first-content" shall be within 500ms on LTE.
- Efficiency (battery): Background prefetch is capped to X MB/day and respects battery saver.
- Scalability: System sustains 20x normal traffic without manual intervention, with p95 latency degradation bounded to +200ms.



NFRs related to Continuity of Service

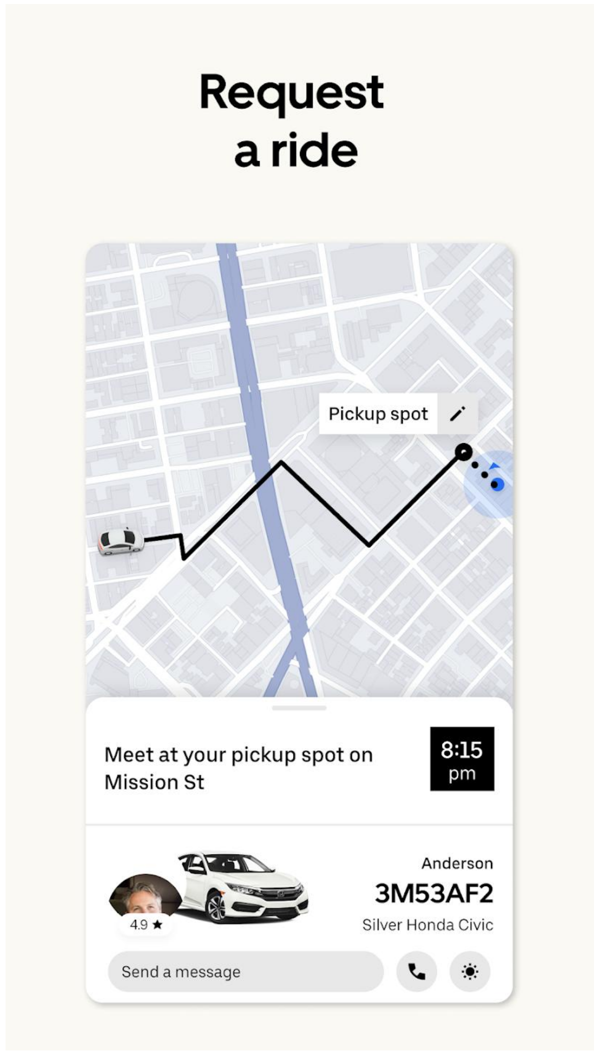
normal use

- Availability: The probability the system is available at a particular instant in time
  - e.g., up time of XX%
- Reliability: The probability that a system will perform within its design limits without failure over time
  - e.g., XX% of success rate
- Robustness: Ability to respond adequately to unanticipated runtime conditions
  - e.g., does not crash given the invalid user input of XX
- Fault-tolenrance: Ability to respond gracefully to failures at runtime (from environment, components, connectors, component-connector mismatches, etc.)
  - e.g., can continue operate with X number of nodes fail
- Survivability: Ability to resist, recover, and adapt to threats (attacks, failures, accidents, etc.)
  - e.g., redundancy in infrastructure to ensure continuous operation during cyber-attacks or natural disasters

when things go wrong

NFRs related to Continuity of Service - Example

- Ride sharing app
- Availability: The "request ride" core feature shall has 99.9% monthly availability.
- ...at peak times (e.g., on New Year's Eve)
- Robustness: The app shall handle intermittent connectivity without crashing; there should be clear notifications.
- Fault-tolerance: If one map provider fails, fall back to another or to cached maps.
- Survivability: During partial outage, preserve essential service and allow ongoing rides to complete.

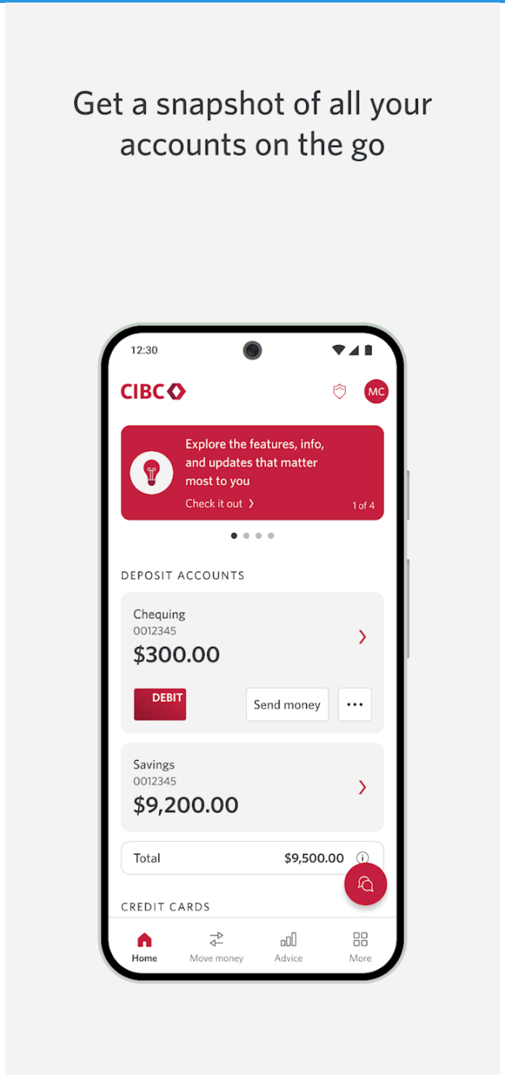


NFRs related to Harm Prevention

- Security: How well the system protects users from external attacks
  - e.g., multi-factor authentication to protect user accounts from unauthorized access
- Privacy: How a system protects the private information of the user
  - e.g., end-to-end encryption for private messages
- Safety: Ability to avoid failures that will cause loss of life, injury, or loss to property
  - e.g., collision detection in autonomous driving system

NFRs related to Harm Prevention

- Online banking app
- Threats can include credential theft, device loss, man-in-the-middle attacks, fraud, …
- Security: The app shall require 2nd-factor authentication (message/phone) for high-risk actions.
- Privacy: The app shall acquire user consent before collecting transactions data for analytics.
- Safety: For transfers to a new payee, the app shall enforce a cooling-off period before the transfer can be completed.



NFRs related to Ecosystem

- Portability: Ability to execute on multiple platforms while retaining their functional and non-functional properties
  - e.g., runs on Windows, MacOS, and Linux
- Heterogeneity: Ability to be composed of, or execute within, disparate parts
  - e.g., consists of X modules implemented in programming languages A B C correspondingly
  - e.g., (fitness tracking app) works across diverse sensors and handles missing sensors gracefully

NFRs related to Development

- Evolvability: Ability to react on change, satisfy new requirements, and add support for new environments
  - e.g., features can be easily added/modified under the modular architecture
- Readability: How well the system is comprehensible to a new developer
  - e.g., every function should have no more than X lines and have comments
- Complexity: The size of a system, the volume of constituent elements, their internal structure, and their interdependencies
  - e.g., consists of X modules, each with around Y lines of code

Exercise: NFRs

- Waterloo Learn course management system
- Discuss and come up with NFRs

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- Usability
- Accessibility

performance
- Efficiency
- Scalability

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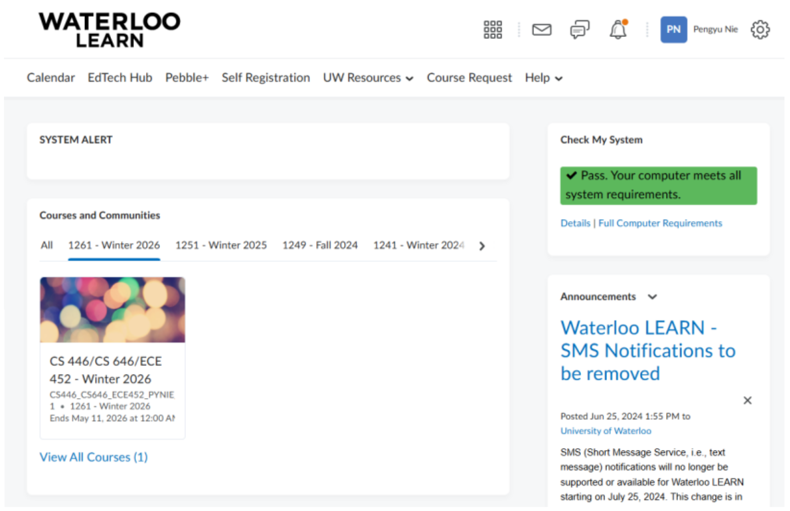

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CS 446/CS 646/ECE 452 - Winter 2026
CS446_CS646_ECE452_PYNIE
1 • 1261 - Winter 2026
Ends May 11, 2026 at 12:00 AM

View All Courses (1)

Check My System

✓ Pass. Your computer meets all system requirements.

Details | Full Computer Requirements

Announcements

Waterloo LEARN - SMS Notifications to be removed

Posted Jun 25, 2024 1:55 PM to University of Waterloo

SMS (Short Message Service, i.e., text message) notifications will no longer be supported or available for Waterloo LEARN starting on July 25, 2024. This change is in

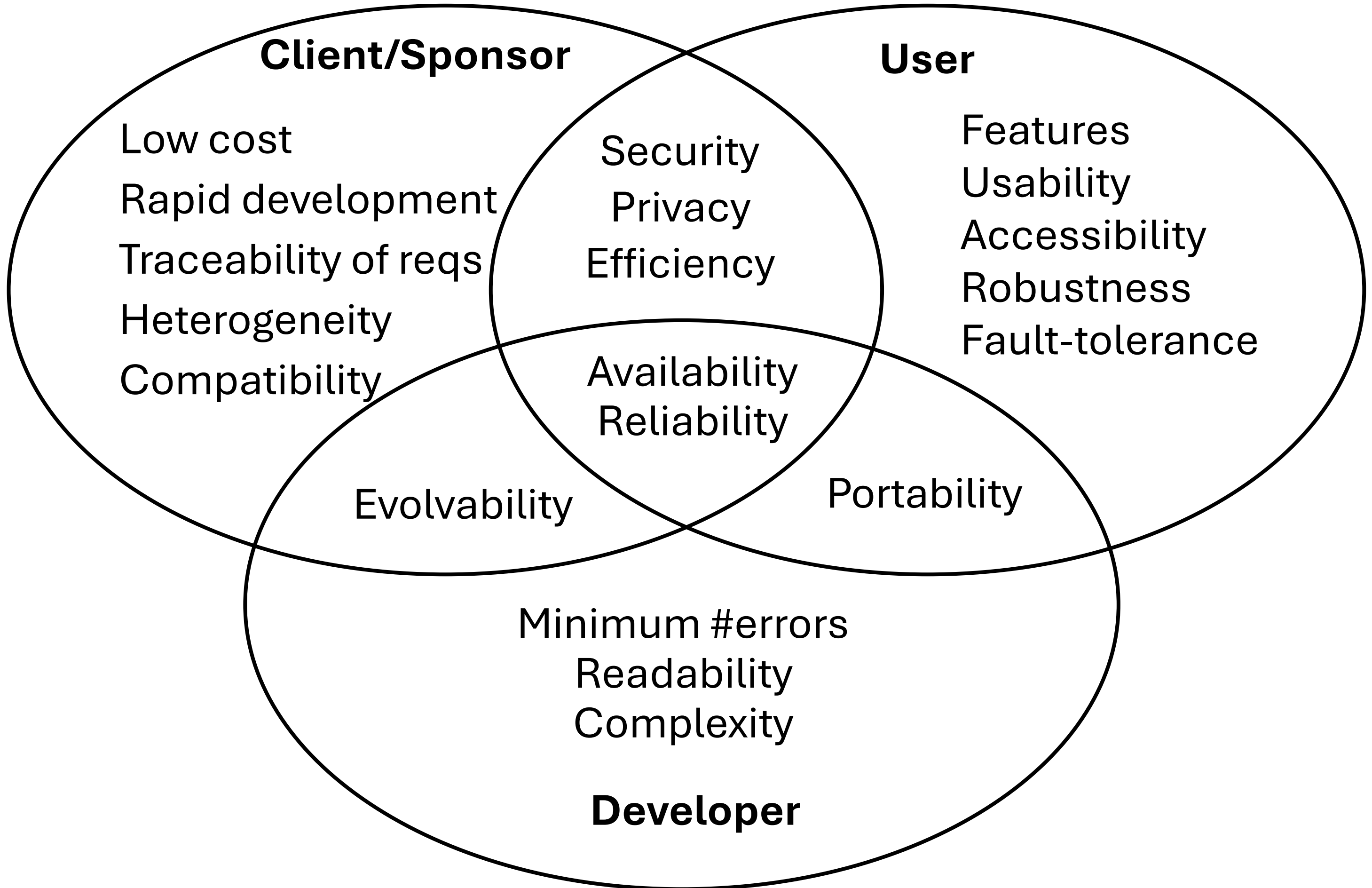
Evaluating NFRs

- Think about NFRs concretely
  - how can they be measured?
  - use specific numbers/cases/items

	Good	Bad
Efficiency	The system shall issue new tickets in under 10 seconds	The system shall issue tickets quickly
Usability	The system shall enable a user with no training to buy tickets in four clicks or less	The system shall be user-friendly

Stakeholder Conflicts on NFRs

- Each stakeholder will have their own opinion about what (non-functional) requirements matter most



Typical Tradeoffs

- Security vs. Usability
- Functionality vs. Usability
  - lots of features vs. simple flows
- Evolvability vs. Cost
  - reusable components vs. one-off delivery
- Efficiency vs. Portability
  - native optimizations vs. runs everywhere

Recap

- Functional vs. non-functional requirements
- Types of non-functional requirements
- Conflicts & tradeoffs

user experience
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- Reminder: P0 team formation due this Friday