LTAT.05.003
Software Engineering

Lecture 03:
Requirements Engineering
– Part 2

Fall 2018

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Schedule of Lectures

Week 01: Introduction to SE
Week 02: Requirements Engineering I
**Week 03: Requirements Engineering II**
Week 04: Analysis
Week 05: Development Infrastructure I
Week 06: Development Infrastructure II
Week 07: Architecture and Design
Week 08: Verification and Validation I
Week 09: Verification and Validation II

Week 10: Continuous Development and Integration
Week 11: Refactoring (and TDD)
Week 12: Agile/Lean Methods
Week 13: no lecture
Week 14: Software Craftsmanship
Week 15: Course wrap-up, review and exam preparation
Use Case Diagrams and Descriptions

Use Case Description:
Name of Use Case
Actors associated with Use Case
Pre-conditions
Post-conditions
Normal Flow of Events (Basic Scenario)
Alternative Flow of Events (Alternative Scenarios)
...

Use Case Model

- Actors
- Use Cases
- Use-Case Descriptions
Use Case Diagram: Device Control

UC1: Unlock
UC2: Lock
UC3: AddUser
UC4: RemoveUser
UC5: InspectAccessHistory
UC6: SetDevicePrefs
UC7: AuthenticateUser
UC8: Login

First tier use cases

Second tier use cases

actor

system boundary

Tenants

Landlords

LockDevice

LightSwitch

Timer

communication

use case

UC1: Unlock

UC2: Lock

UC7: AuthenticateUser

UC1: Unlock
UC2: Lock
UC3: AddUser
UC4: RemoveUser
UC5: InspectAccessHistory
UC6: SetDevicePrefs
UC7: AuthenticateUser
UC8: Login
# Schema for Use Case Description

<table>
<thead>
<tr>
<th>Use Case UC-#</th>
<th>Name / Identifier</th>
<th>[verb phrase]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related Requirements</td>
<td>List of the requirements that are addressed by this use case</td>
<td></td>
</tr>
<tr>
<td>Initiating Actor</td>
<td>Actor who initiates interaction with the system to accomplish a goal</td>
<td></td>
</tr>
<tr>
<td>Actor's Goal</td>
<td>Informal description of the initiating actor's goal</td>
<td></td>
</tr>
<tr>
<td>Participating Actors</td>
<td>Actors that will help achieve the goal or need to know about the outcome</td>
<td></td>
</tr>
<tr>
<td>Preconditions</td>
<td>What is assumed about the state of the system before the interaction starts</td>
<td></td>
</tr>
<tr>
<td>Postconditions</td>
<td>What are the results after the goal is achieved or abandoned; i.e., what must be true about the system at the time the execution of this use case is completed</td>
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### Flow of Events for Main Success Scenario:

1. The initiating actor delivers an action or stimulus to the system (the arrow indicates the direction of interaction, to- or from the system)
2. The system's reaction or response to the stimulus; the system can also send a message to a participating actor, if any
3. ...  

### Flow of Events for Extensions (Alternate Scenarios):
What could go wrong? List the exceptions to the routine and describe how they are handled

1a. For example, actor enters invalid data
2a. For example, power outage, network failure, or requested data unavailable

The arrows on the left indicate the direction of interaction:  → Actor's action;  ← System's reaction
Project Estimation

with

Use Cases
Use Case Points

For the sum of all Use Cases:

- UCP equation is composed of four variables:
  - Unadjusted Use Case Point (UUCP)
  - The Technical Complexity Factor (TCF)
  - The Environment Complexity Factor (ECF)

  \[(\text{adjusted}) \quad \text{UCP} = \text{UUCP} \times \text{TCF} \times \text{ECF}\]

- UUCP is the sum of Unadjusted Actor Weight (UAW) and Unadjusted Use Case Weight (UUCW).

  \[\text{UUCP} = \text{UAW} + \text{UUCW}\]

unadjusted
# Unadjusted Actor Weight

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<th>Actor Type</th>
<th>Description</th>
<th>Weight</th>
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<tbody>
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<td>Interacts with the system through some protocol (HTTP, FTP, or probably some user defined protocol), or Are data stores (Files, DBMS)</td>
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</tr>
<tr>
<td>Complex</td>
<td>Interacts through HCI (GUI)</td>
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\[
\text{UAW} = (\text{Total No. of Simple actors} \times 1) + (\text{Total No. Average actors} \times 2) + (\text{Total No. Complex actors} \times 3)
\]
# Unadjusted Use Case Weight

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<tr>
<td>Complex</td>
<td>8 or more transactions</td>
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\[
UUCW = (\text{Total No. of Simple Use Cases} \times 5) + (\text{Total No. Average Use Case} \times 10) + (\text{Total No. Complex Use Cases} \times 15)
\]
# Schema for Use Case Description

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2. The system's reaction or response to the stimulus; the system can also send a message to a participating actor,
3. ...

### Flow of Events for Extensions (Alternate Scenarios):

1a. For example, actor enters invalid data
2a. For example, power outage, network failure, or requested data unavailable
...

The arrows on the left indicate the direction of interaction: → Actor's action; ← System's reaction

**5 Transactions**
## Technical Complexity Factor – TCF

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<td>Distributed System</td>
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<td>TF(2)</td>
<td>Performance</td>
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<tr>
<td>TF(3)</td>
<td>End User Efficiency</td>
<td>1</td>
</tr>
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<td>TF(4)</td>
<td>Complex Internal Processing</td>
<td>1</td>
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<td>TF(5)</td>
<td>Reusability</td>
<td>1</td>
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<tr>
<td>TF(6)</td>
<td>Installability</td>
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<td>TF(7)</td>
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<td>TF(12)</td>
<td>Provides direct access by third parties</td>
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<td>TF(13)</td>
<td>Special User training facilities are required</td>
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Each TF(i) can have a value from 0 (factor is irrelevant) to 5 (factor is essential)

\[
\text{TCF} = 0.6 + \frac{\text{TF}}{100} \text{ with } \text{TF} = \sum_{i=1}^{13} (\text{TF}(i) \times \text{Weight}(i))
\]
# Environmental Complexity Factor - ECF

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<th>Description</th>
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</thead>
<tbody>
<tr>
<td>EF(1)</td>
<td>Familiarity with system development process in use</td>
<td>1.5</td>
</tr>
<tr>
<td>EF(2)</td>
<td>Application experience</td>
<td>0.5</td>
</tr>
<tr>
<td>EF(3)</td>
<td>Object-oriented experience</td>
<td>1.0</td>
</tr>
<tr>
<td>EF(4)</td>
<td>Lead analyst capability</td>
<td>0.5</td>
</tr>
<tr>
<td>EF(5)</td>
<td>Motivation</td>
<td>1.0</td>
</tr>
<tr>
<td>EF(6)</td>
<td>Requirements stability</td>
<td>2.0</td>
</tr>
<tr>
<td>EF(7)</td>
<td>Part time staff</td>
<td>-1.0</td>
</tr>
<tr>
<td>EF(8)</td>
<td>Difficulty of programming language</td>
<td>-1.0</td>
</tr>
</tbody>
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Each EF(i) can have a value from 0 (no experience) to 5 (expert)

Complexity increases, the smaller EF(1) to EF(6) and the greater EF(7) & EF(8)

ECF = 1.4 + (-0.03*EF) with $EF = \sum_{i=1}^{8}(EF(i) \times Weight(i))$
Use Case Points

For the sum of all Use Cases:

- UCP equation is composed of four variables:
  - Unadjusted Use Case Point (UUCP)
  - The Technical Complexity Factor (TCF)
  - The Environment Complexity Factor (ECF)

\[
\text{UCP} = \text{UUCP} \times \text{TCF} \times \text{ECF}
\]

- UUCP is the sum of Unadjusted Actor Weight (UAW) and Unadjusted Use Case Weight (UUCW).

\[
\text{UUCP} = \text{UAW} + \text{UUCW}
\]
Use Case Points

For the sum of all Use Cases:

- UCP equation is composed of four variables:
  - Unadjusted Use Case Point (UUCP)
  - The Technical Complexity Factor (TCF)
  - The Environment Complexity Factor (ECF)
  - The Productivity Factor (PF)

\[
\text{Effort (UCP)} = \text{UUCP} \times \text{TCF} \times \text{ECF} \times \text{PF}
\]

- UUCP is the sum of Unadjusted Actor Weight (UAW) and Unadjusted Use Case Weight (UUCW).

\[
\text{UUCP} = \text{UAW} + \text{UUCW}
\]
Use Case Points: Project Effort

For the sum of all Use Cases:

- The Unadjusted Use Case Point (UUCP)
- The Technical Complexity Factor (TCF)
- The Environment Complexity Factor (ECF)
- The Productivity Factor (PF)

\[
\text{Eff}(UCP) = \text{UUCP} \times \text{TCF} \times \text{ECF} \times \text{PF} \quad \text{[person-hours]}
\]

Either 20 person-hours/UCP or 28 person-hours/UCP

- UUCP is the sum of Unadjusted Actor Weight (UAW) and Unadjusted Use Case Weight (UUCW).

\[
\text{UUCP} = \text{UAW} + \text{UUCW}
\]
Productivity Factor - PF

If sum of [(number of factors E1 through E6 assigned value < 3) and (number of factors E7 and E8 assigned value > 3)] ≤ 2

\[ PF = 20 \text{ ph/UCP} \]

Else
If sum of [(number of factors E1 through E6 assigned value < 3) and (number of factors E7 and E8 assigned value > 3)] = 3 or 4

\[ PF = 28 \text{ ph/UCP} \]

Else: Rethink project; it has too high a risk of failure

Example: http://en.wikipedia.org/wiki/Use_Case_Points

Complexity increases, the smaller EF(1) to EF(6) and the greater EF(7) & EF(8)

EF values: 0, 1, 2, 3, 4, 5
Example

Assume the following UC diagram

- **Landlord**
  - «initiate» UC3: AddUser
  - «participate» UC4: RemoveUser
  - «initiate» UC5: InspectAccessHistory
  - «initiate» UC6: SetDevicePrefs

- **Tenant**
  - «initiate» UC3: AddUser
  - «initiate» UC4: RemoveUser
  - «initiate» UC5: InspectAccessHistory
  - «initiate» UC6: SetDevicePrefs

Account Management Subsystem

UC8: Login
Example

How much effort will this subsystem need?

Assume the following UC diagram

- **UC3: AddUser**
- **UC4: RemoveUser**
- **UC5: InspectAccessHistory**
- **UC6: SetDevicePrefs**
- **UC8: Login**

**Account Management Subsystem**

- Tenant
- Landlord
Example

How much effort will this subsystem need?

Assume the following UC diagram

To calculate:

\[ \text{Eff(UCP)} = \text{UUCP} \times \text{TCF} \times \text{ECF} \times \text{PF} \text{ [person-hours]} \]
\[ = (\text{UAW} + \text{UUCW}) \times \text{TCF} \times \text{ECF} \times \text{PF} \text{ [person-hours]} \]

Unadjusted Actor Weight

Unadjusted Use Case Weight

Technical Complexity Factor

Environmental Complexity Factor

Productivity Factor
Example

Assume the following UC diagram

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2 Actors

UC6: SetDevicePrefs
Example

Assume the following UC diagram

2 Actors

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Unadjusted Actor Weight?

UAW = 3 + 3 = 6
Example

Assume the following UC diagram

- Tenant
- Landlord

Account Management Subsystem

- UC3: AddUser
- UC4: RemoveUser
- UC5: InspectAccessHistory
- UC6: SetDevicePrefs
- UC8: Login

5 UCs

Use Case Weight?

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Example

Assume the following UC diagram

5 UCs

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Example

Assume the following UC diagram

Account Management Subsystem

- UC3: AddUser
- UC4: RemoveUser
- UC5: InspectAccessHistory
- UC6: SetDevicePrefs
- UC8: Login

5 UCs

Unadjusted Use Case Weight?

Has 4 transactions (not counting UC8)

Weight = 10

5 UCs

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Example

Assume the following UC diagram

Unadjusted Use Case Weight?

\[ UUCW = 10 + 5 + 10 + 5 + 5 = 25 \]

5 UCs

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Example

How much effort will this subsystem need?

Assume the following UC diagram

To calculate:

\[
\text{Eff}(UCP) = \text{UUCP} \times \text{TCF} \times \text{ECF} \times \text{PF}\ [\text{person-hours}]
\]

\[
= (\text{UAW} + \text{UUCW}) \times \text{TCF} \times \text{ECF} \times \text{PF}\ [\text{person-hours}]
\]

Unadjusted Actor Weight

Unadjusted Use Case Weight

Technical Complexity Factor

Environmental Complexity Factor

Productivity Factor
Example

How much effort will this subsystem need?

Assume the following UC diagram

To calculate:

\[
\text{Eff}(UCP) = 31 \times \text{TCF} \times \text{ECF} \times \text{PF} \text{ [person-hours]}
= (6 + 25) \times \text{TCF} \times \text{ECF} \times \text{PF} \text{ [person-hours]}
\]

Unadjusted Actor Weight

Unadjusted Use Case Weight

Technical Complexity Factor

Productivity Factor

Environmental Complexity Factor
Example

Assume the following UC diagram

Account Management Subsystem

- UC3: AddUser
- UC4: RemoveUser
- UC5: InspectAccessHistory
- UC6: SetDevicePrefs
- UC8: Login

- Tenant «initiate» UC3: AddUser
- Tenant «participate» UC4: RemoveUser
- Tenant «initiate» UC5: InspectAccessHistory
- Tenant «initiate» UC6: SetDevicePrefs
- Landlord «initiate» UC4: RemoveUser
- Landlord «include» UC5: InspectAccessHistory
- Landlord «include» UC6: SetDevicePrefs
- Landlord «initiate» UC8: Login

Technical Complexity Factor?
Example

Technical Complexity Factor?

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TCF = 0.6 + TF/100 with \[TF = \sum_{i=1}^{13}(TF(i) \times Weight(i))\]
### Example

**Technical Complexity Factor?**

Each TF(i) can have a value from 0 (factor is irrelevant) to 5 (factor is essential).

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<td>TF(3)</td>
<td>End User Efficiency</td>
<td>1</td>
</tr>
<tr>
<td>TF(4)</td>
<td>Complex Internal Processing</td>
<td>1</td>
</tr>
<tr>
<td>TF(5)</td>
<td>Reusability</td>
<td>1</td>
</tr>
<tr>
<td>TF(6)</td>
<td>Installability</td>
<td>0.5</td>
</tr>
<tr>
<td>TF(7)</td>
<td>Usability</td>
<td>0.5</td>
</tr>
<tr>
<td>TF(8)</td>
<td>Portability</td>
<td>2</td>
</tr>
<tr>
<td>TF(9)</td>
<td>Modifiability</td>
<td>1</td>
</tr>
<tr>
<td>TF(10)</td>
<td>Concurrency</td>
<td>1</td>
</tr>
<tr>
<td>TF(11)</td>
<td>Includes special security requirements</td>
<td>1</td>
</tr>
<tr>
<td>TF(12)</td>
<td>Provides direct access by third parties</td>
<td>1</td>
</tr>
<tr>
<td>TF(13)</td>
<td>Special User training facilities are required</td>
<td>1</td>
</tr>
</tbody>
</table>

TF = 3*2 + 4*1 + 3*1 + 2*1 + 3*0.5 + 5*0.5 + 1*2 + 2*1 + 1*1 + 5*1 + 3*1 + 2*1 = 34

TCF = 0.6 + TF/100 = 0.6 + 0.34 = 0.94

**TCF = 0.94**
Example

Assume the following UC diagram

Environmental Complexity Factor?
Example

Environmental Complexity Factor?

<table>
<thead>
<tr>
<th>Factor Number</th>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF(1)</td>
<td>Familiarity with system development process in use</td>
<td>1.5</td>
</tr>
<tr>
<td>EF(2)</td>
<td>Application experience</td>
<td>0.5</td>
</tr>
<tr>
<td>EF(3)</td>
<td>Object-oriented experience</td>
<td>1.0</td>
</tr>
<tr>
<td>EF(4)</td>
<td>Lead analyst capability</td>
<td>0.5</td>
</tr>
<tr>
<td>EF(5)</td>
<td>Motivation</td>
<td>1.0</td>
</tr>
<tr>
<td>EF(6)</td>
<td>Requirements stability</td>
<td>2.0</td>
</tr>
<tr>
<td>EF(7)</td>
<td>Part time staff</td>
<td>-1.0</td>
</tr>
<tr>
<td>EF(8)</td>
<td>Difficulty of programming language</td>
<td>-1.0</td>
</tr>
</tbody>
</table>

ECF = 1.4 + (-0.03*EF) with EF = \( \sum_{i=1}^{8}(EF(i) \times \text{Weight}(i)) \)
Example

Environmental Complexity Factor?

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<tr>
<th>Factor Number</th>
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</tr>
<tr>
<td>EF(2) 4</td>
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<td>0.5</td>
</tr>
<tr>
<td>EF(3) 5</td>
<td>Object-oriented experience</td>
<td>1.0</td>
</tr>
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<td>EF(4) 4</td>
<td>Lead analyst capability</td>
<td>0.5</td>
</tr>
<tr>
<td>EF(5) 3</td>
<td>Motivation</td>
<td>1.0</td>
</tr>
<tr>
<td>EF(6) 3</td>
<td>Requirements stability</td>
<td>2.0</td>
</tr>
<tr>
<td>EF(7) 0</td>
<td>Part time staff</td>
<td>-1.0</td>
</tr>
<tr>
<td>EF(8) 1</td>
<td>Difficulty of programming language</td>
<td>-1.0</td>
</tr>
</tbody>
</table>

Each EF(i) can have a value from 0 (no experience) to 5 (expert)

ECF = 1.4 + (-0.03*EF) with EF = \( \sum_{i=1}^{8} (EF(i) \times \text{Weight}(i)) \)
### Environmental Complexity Factor?

Each EF(i) can have a value from 0 (no experience) to 5 (expert).

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EF = 2*1.5 + 4*0.5 + 5*1 + 4*0.5 + 3*1 + 3*2 + 0*(-1) + 1*(-1) = 20
ECF = 1.4 + (-0.03*EF) = 1.4 – 0.6 = 0.8

TCF = 0.8
Example

How much effort will this subsystem need?

Assume the following UC diagram

To calculate:

\[ \text{Eff}(UCP) = 31 \times \text{TCF} \times \text{ECF} \times \text{PF} \text{ [person-hours]} \]
\[ = (6 + 25) \times \text{TCF} \times \text{ECF} \times \text{PF} \text{ [person-hours]} \]

Unadjusted Actor Weight

Unadjusted Use Case Weight

Productivity Factor

Environmental Complexity Factor

Technical Complexity Factor
Example

How much effort will this subsystem need?

Assume the following UC diagram

To calculate:

\[
\text{Eff(UCP)} = 31 \times 0.94 \times 0.8 \times \text{PF} \text{ [person-hours]}
\]

\[
= (6 + 25) \times 0.94 \times 0.8 \times \text{PF} \text{ [person-hours]}
\]
Productivity Factor - PF

If sum of [(number of factors E1 through E6 assigned value < 3) and (number of factors E7 and E8 assigned value > 3)] ≤ 2

PF = 20 ph/UCP

Else
If sum of [(number of factors E1 through E6 assigned value < 3) and (number of factors E7 and E8 assigned value > 3)] = 3 or 4

PF = 28 ph/UCP

Else: Rethink project; it has too high a risk of failure

Example: http://en.wikipedia.org/wiki/Use_Case_Points
Productivity Factor - PF

If \( \text{sum of } \left( \text{number of factors } E1 \text{ through } E6 \text{ assigned value } < 3 \right) \text{ and } \left( \text{number of factors } E7 \text{ and } E8 \text{ assigned value } > 3 \right) \leq 2 \)

\[ \text{PF} = 20 \text{ ph/UCP} \]

Else

If \( \text{sum of } \left( \text{number of factors } E1 \text{ through } E6 \text{ assigned value } < 3 \right) \text{ and } \left( \text{number of factors } E7 \text{ and } E8 \text{ assigned value } > 3 \right) = 3 \text{ or } 4 \)

\[ \text{PF} = 28 \text{ ph/UCP} \]

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Complexity increases, the smaller EF(1) to EF(6) and the greater EF(7) & EF(8)

EF values: 0, 1, 2, 3, 4, 5
Productivity Factor - PF

PF = 20 ph/UCP

If sum of [(number of factors E1 through E6 assigned value < 3)
and (number of factors E7 and E8 assigned value > 3)] ≤ 2

PF = 28 ph/UCP

Else:

Rethink project; it has too high a risk of failure

Example: http://en.wikipedia.org/wiki/Use_Case_Points

Factor Number | Description                  | Weight
----------------|------------------------------|--------
EF(1)          | Familiarity with system development process in use | 1.5
EF(2)          | Application experience       | 0.5
EF(3)          | Object-oriented experience   | 1.0
EF(4)          | Lead analyst capability      | 0.5
EF(5)          | Motivation                   | 1.0
EF(6)          | Requirements stability       | 2.0
EF(7)          | Part time staff              | -1.0
EF(8)          | Difficulty of programming language | -1.0

Complexity increases, the smaller EF(1) to EF(6) and the greater EF(7) & EF(8)
Productivity Factor - PF

If \( \left( \text{number of factors E1 through E6 assigned value } < 3 \right) + \left( \text{number of factors E7 and E8 assigned value } > 3 \right) \leq 2 \)

\[ PF = 20 \text{ ph/UCP} \]

Else:
If \( \left( \text{number of factors E1 through E6 assigned value } < 3 \right) + \left( \text{number of factors E7 and E8 assigned value } > 3 \right) = 3 \text{ or } 4 \)

\[ PF = 28 \text{ ph/UCP} \]

Rethink project; it has too high a risk of failure

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Example: EF values: 0, 1, 2, 3, 4, 5
Example

How much effort will this subsystem need?

Assume the following UC diagram

To calculate:

\[
\text{Eff}(UCP) = 31 \times 0.94 \times 0.8 \times PF \text{ [person-hours]}
\]

\[
= (6 + 25) \times 0.94 \times 0.8 \times PF \text{ [person-hours]}
\]
Example

How much effort will this subsystem need?

Assume the following UC diagram

To calculate:

\[ \text{Eff(UCP)} = 31 \times 0.94 \times 0.8 \times 20 \text{ [person-hours]} \]
\[ = (6 + 25) \times 0.94 \times 0.8 \times 20 \text{ [person-hours]} \]

Unadjusted Actor Weight
Unadjusted Use Case Weight
Technical Complexity Factor
Environmental Complexity Factor
Productivity Factor

\[ \text{Eff(UCP)} = 466 \text{ p-hours} = 11.66 \text{ p-weeks} \]
Example

How much effort will this subsystem need?

Eff(UCP) = 466 p-hours = 11.66 p-weeks

A team of 6 developers could do this in a 2-weeks sprint.