An Empirical Investigation of Software Engineers' Ability to Classify Cross References

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utline

- Background and Motivation
- Research Design
- Findings & Summary

Problem Statement

Legal cross-references introduce challenges to regulatory compliance, including: ambiguities, exceptions and conflicts.

Software engineers need guidance as to how to address cross-reference to achieve compliance with legal requirements.

egulatory Impacts on equirements Engineers

As laws change, software must be adapted to remai in compliance

Legacy systems may have to be rearchitected

New systems and upgrades may have to be deployed

Requirements engineers need guidance and tools to understand changes and impact to their software

oftware Engineering

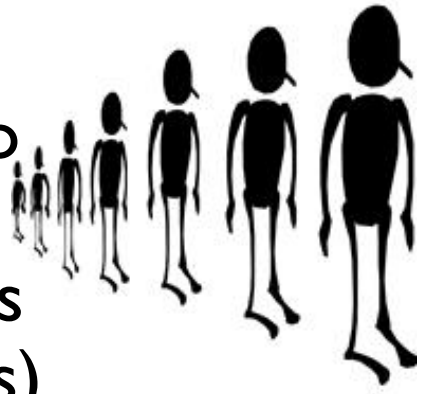
The application of a systematic approach to building, maintaining, and verifying software that must comply with laws and regulations.

w U.S. Regulations are Developed

1. Congress passes a statute

2. Regulatory ager releases propose regulations (rules) b on authority in stat

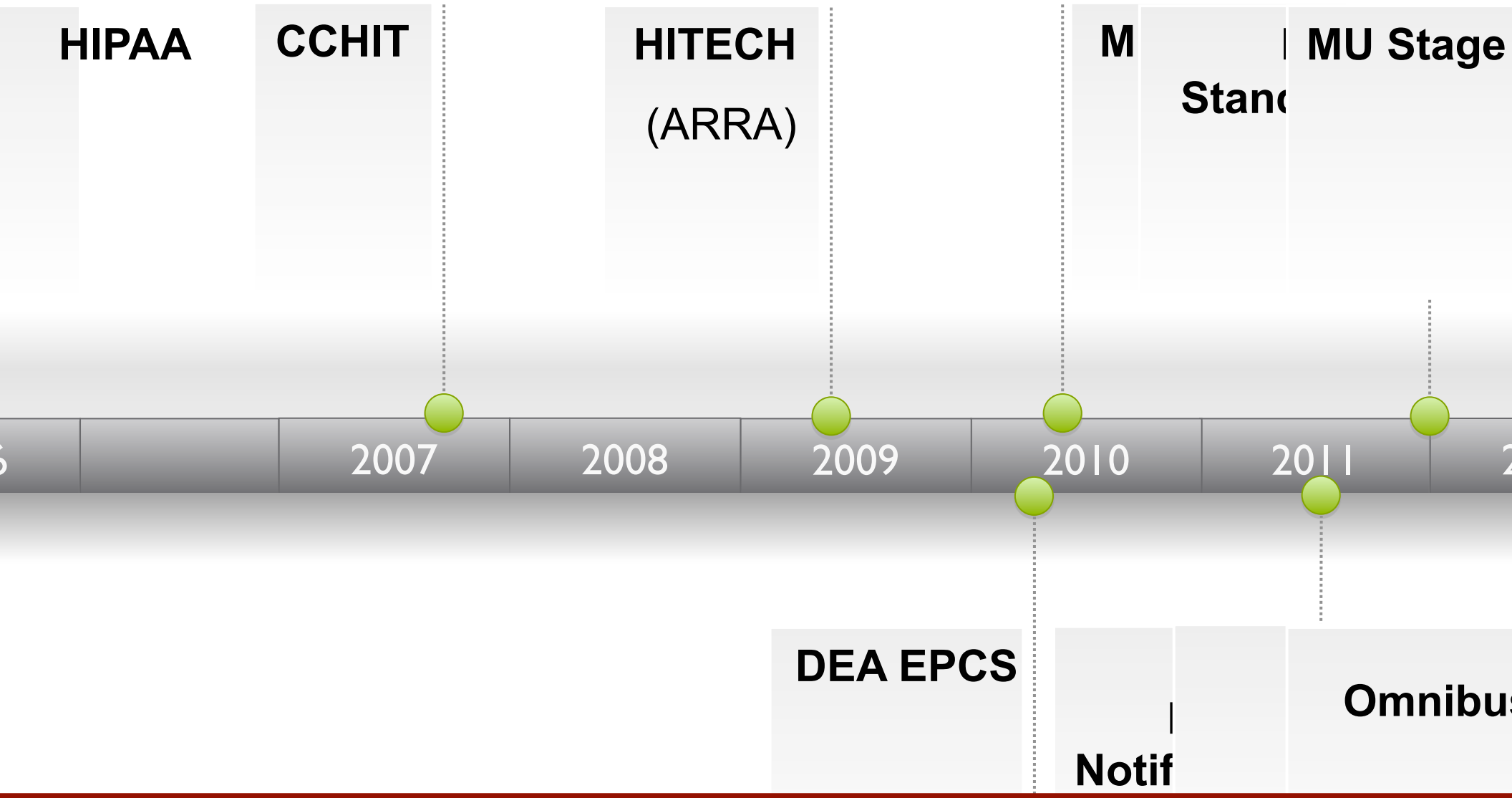
ublic has rtunity to ment on osed rules y 60 days)



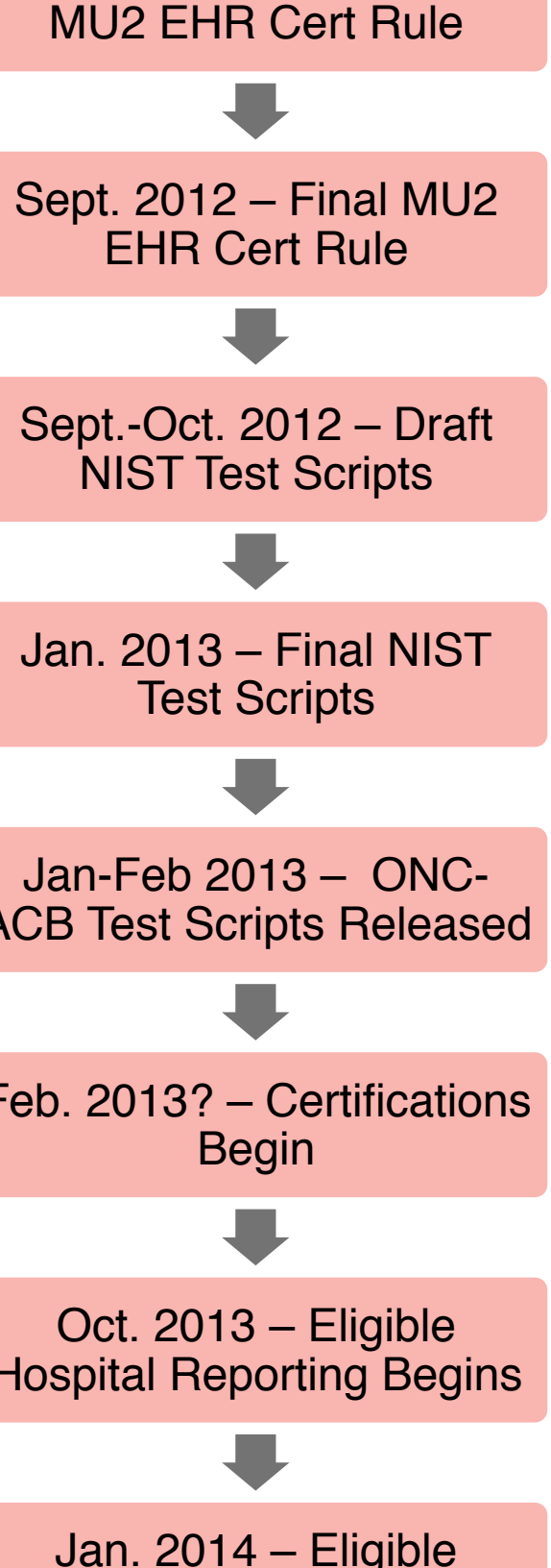
4. Regulatory ager responds to comm & releases final ru that are binding on regulated industr

5. Industry must comply with rules by enforcement date

egulation



Various State Laws



are Often Too Compressed

- EHR developers will have less than 8 months to develop features, certify their EHRs, a install at physician practices a hospitals
- When engineers miss compli deadlines:
  - Financial penalties
  - Reputational damage
  - Lost sales

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elated Work

Legal compliance in requirements engineering

- Goals [AE04, GAP09, SPS09]
- Frames [BA08, Bre09]
- Traceability links [CCG10, GAP07, GAP09]
- Internal cross-references [MOA09, MGL06]
- Triage [MOA09, MSO11]

Software and compliance requirements evolution

- Software artifact evolution [AP03, Boh96, BL76, MS01, Par94]
- Formal methods [Gho99, LX93, Nik09, ZO97]
- Mining software repositories [KH07, YMN04, ZWD04]

Knowledge representation

- Logic programming [BRR87, SKB91, SSK86, She87]

pecifications ....

nternal vs. External)

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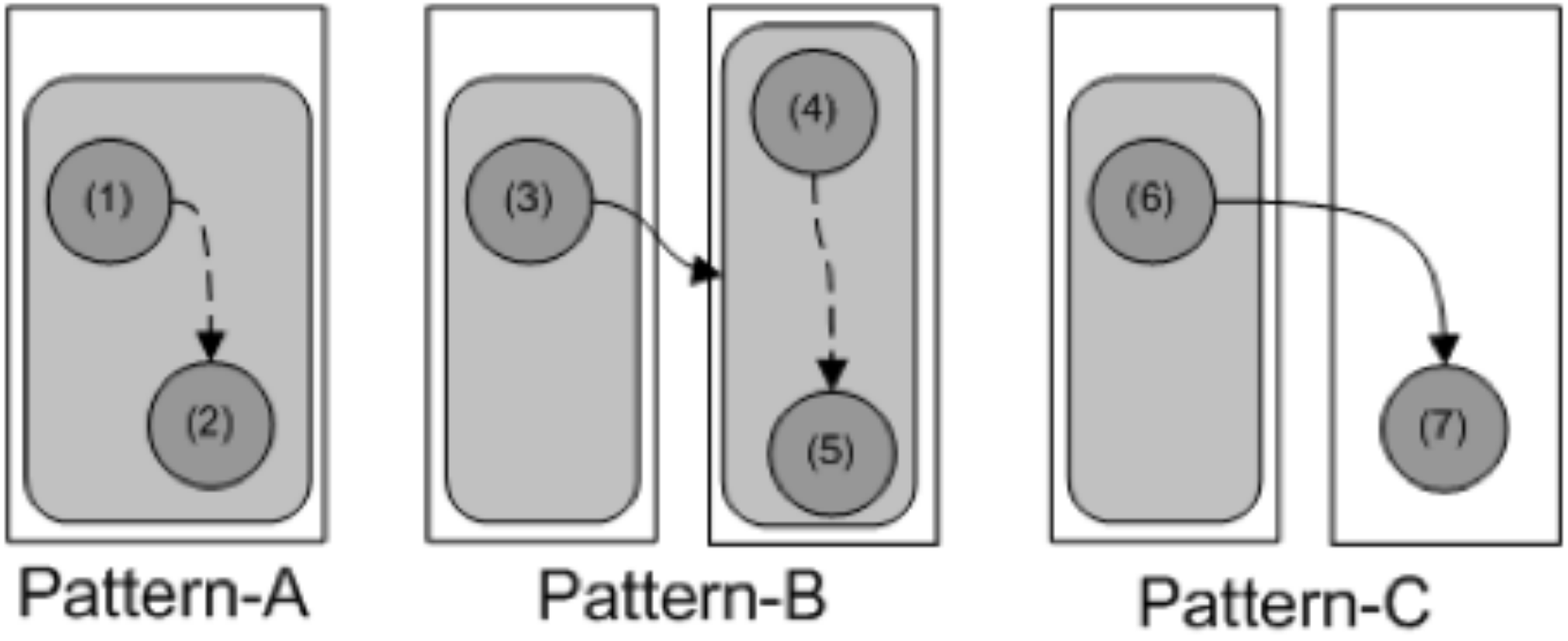

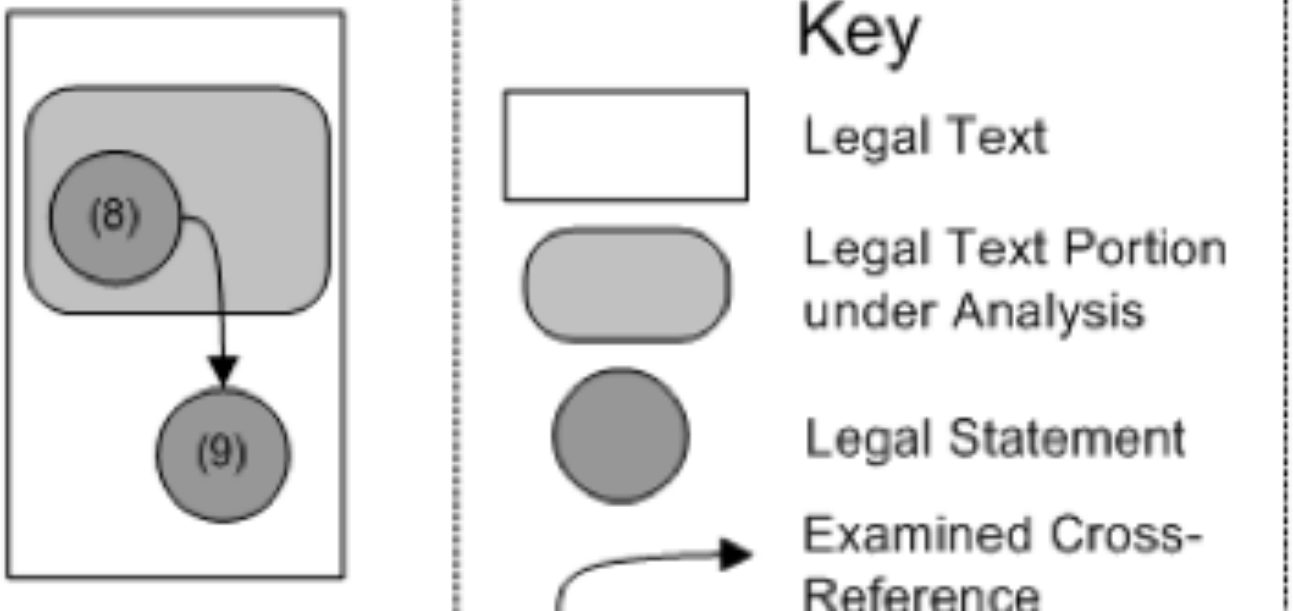

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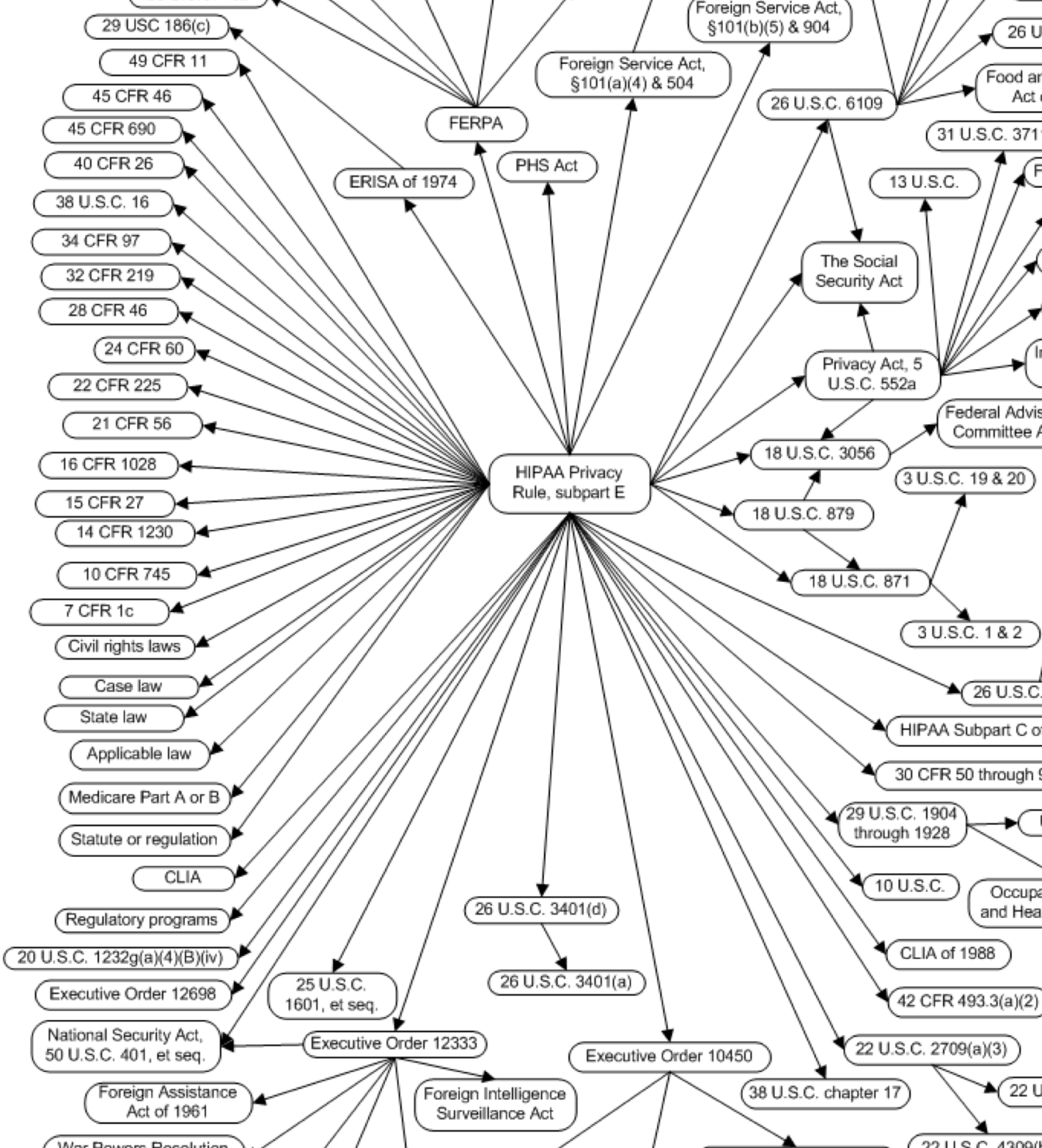

axonomy

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Constraint

Add additional constraints to existing compliance requirements

Exception

Introduces an exception condition to an existing compliance requirement

Definition

Introduces a definition or term

Unrelated

The referencing or referenced legal texts do not yield software requirements

Incorrect

Cite an incorrect portion of a legal text

General

Do not cite a specific legal text but rather "applicable law"

Prioritization

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ample Cross Reference

EHR MU1 Certification Rule

170.210(a)(1) (a) *Encryption and decryption of electr*

ealth information—(1) *General*. Any encryption algori

lentified **by the National Institute of Standards and**

echnology (NIST) as an approved security functio

nnex A of the Federal Information Processing

tandards (FIPS) Publication 140–2 (incorporated b

eference in §170.299).

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Empirical Study Design

oal

Test the ability of software engineers, legal
omain experts, and healthcare professionals
o correctly classify cross-references using the
ross-reference taxonomy we previously
eveloped.

aterials

Informed consent form & demographics survey

Tutorial

- Cross Reference Taxonomy w/ examples of each classificat

10 legal statements from 4 healthcare and financial regulations

- Employed statements that were shorter in length
- Ensured each classification was exhibited by at least one cr reference (w/ exception of incorrect CRs)

Participants asked to classify statements using our cross-references taxonomy

Online survey (Qualtrics[3]) — 30 days

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ull Hypothesis

H_0: Individuals from the participant group have
quivalent or greater precision than the expert
assifications when classifying cross-references
sing the taxonomy.

arget Population

Pilot — Realsearch & ThePrivacyPlace research groups (11 began survey; 7 completed)

- Experts — author, privacy prof., law prof., 2 PhD students

Participants recruited from 2 organizations

- An industry trade group of 41 EHR vendors
- A nonprofit consortium of 220 healthcare organization
- Participants — 56 began survey, 33 completed

ipirical Study Participants

		Pilot Study	Full Study
		(# in Role / Median Years Experience	
t Role	Req't Engineer	1 / 8	4 / 12.5
	Software Developer	3 / 3.75	17 / 15
	Quality Engineer	1 / 0	5 / 9.5
	Support / Services	0 / 0	1 / 7
	Network / IT	0 / 0	1 / 3
	Compliance / Legal	1 / 0	3 / 3
	Healthcare Practitioner	0 / 0	2 / 7.5
	Other	2 / 4.5	7 / 11
evious Role	Req't Engineer	2 / 5	5 / 4
	Software Developer	4 / 4.25	20 / 16
	Quality Engineer	0 / 0	6 / 8.5
	Support / Services	0 / 0	8 / 3.5
	Network / IT	0 / 0	6 / 6.5
	Compliance / Legal	0 / 0	1 / 11
	Healthcare Practitioner	0 / 0	5 / 6
	Other	0 / 0	8 / 10

Findings

mpirical Study Observations

Median participant score: 5.5 (out of 10)

Software engineers are not well equipped to understand the impact of cross-references on software requirements (p=0.0002)

Participants with more experience in regulatory domains perform better (p = 0.0548)

Pilot participants performed better than software practitioners (p = 0.0374)

ig Picture Takeaways ….

RCSE is a young, interdisciplinary field with lots of exciting research opportunities in security and priva

Software engineers are ill-equipped to understand legal cross-references & we know from other studies [MAS11] that SE students are ill-prepared to make leg implementation readiness decisions with any confidence.

Subject matter experts must be involved in legal compliance decisions.

ext Steps …

Plan to rerun the study in a graduate-level software engineering course

Two part survey:

1st part: 10 questions, then show participants how they did

2nd part: different set of 10 questions

Our hypothesis: with better training, participants will perform better than participants did in this first study

Thank you!

by Question

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Pilot Study									
Constraint	**71.4**	12.5	12.5	0.0	**28.6**	**11.1**	0.0	0.0	**75.0**
Exception	0.0	0.0	**87.5**	0.0	0.0	11.1	**50.0**	0.0	0.0
Definition	28.6	0.0	0.0	**87.5**	0.0	0.0	50.0	**87.5**	0.0
Unrelated	0.0	12.5	0.0	12.5	**42.9**	0.0	0.0	12.5	12.5
Incorrect	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General	0.0	0.0	0.0	0.0	28.6	**66.7**	0.0	0.0	0.0
Prioritization	0.0	**75.0**	0.0	0.0	0.0	11.1	0.0	0.0	12.5
Full Study									
Constraint	**22.2**	5.9	7.9	3.0	**38.9**	**15.4**	2.2	5.4	**48.6**
Exception	19.4	8.8	**76.3**	0.0	0.0	10.3	**50.0**	0.0	8.1
Definition	11.1	11.8	2.6	**84.8**	16.7	7.7	30.4	**81.1**	16.2
Unrelated	36.1	5.9	0.0	6.1	**25.0**	5.1	8.7	2.7	13.5
Incorrect	0.0	2.9	2.6	0.0	2.8	0.0	2.2	0.0	2.7
General	5.6	5.9	7.9	3.0	11.1	**59.0**	2.2	10.8	8.1
Prioritization	5.6	**58.8**	2.6	3.0	5.6	2.6	4.3	0.0	2.7