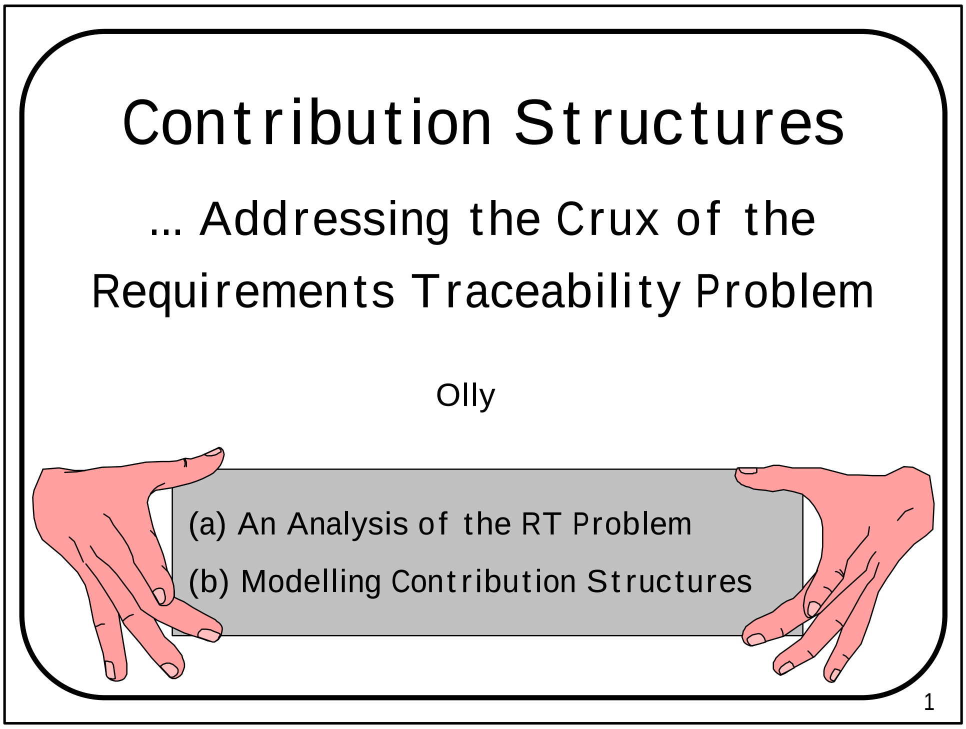


Contribution Structures

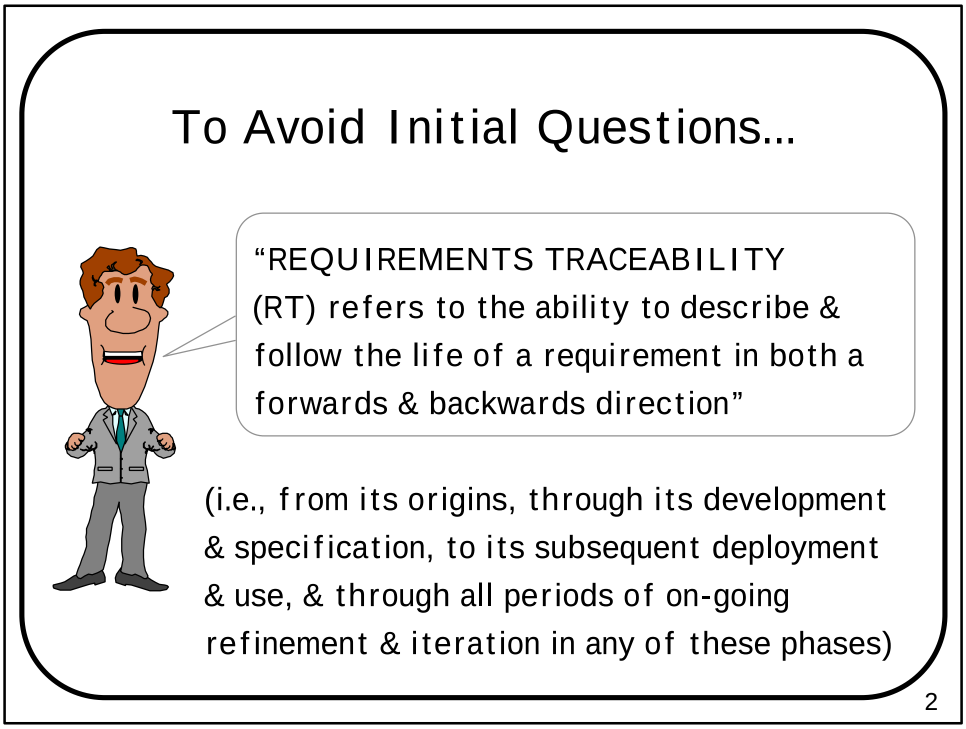
... Addressing the Crux of the Requirements Traceability Problem

Olly

(a) An Analysis of the RT Problem

(b) Modelling Contribution Structures

1

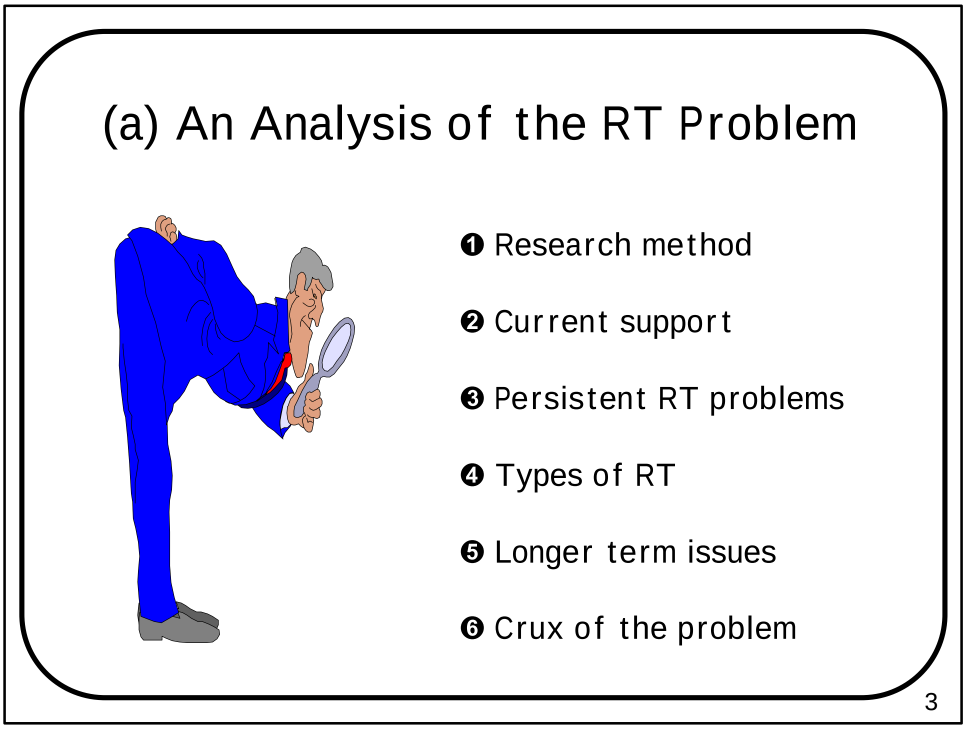


To Avoid Initial Questions...

"REQUIREMENTS TRACEABILITY (RT) refers to the ability to describe & follow the life of a requirement in both a forwards & backwards direction"

(i.e., from its origins, through its development & specification, to its subsequent deployment & use, & through all periods of on-going refinement & iteration in any of these phases)

2



(a) An Analysis of the RT Problem

❶ Research method

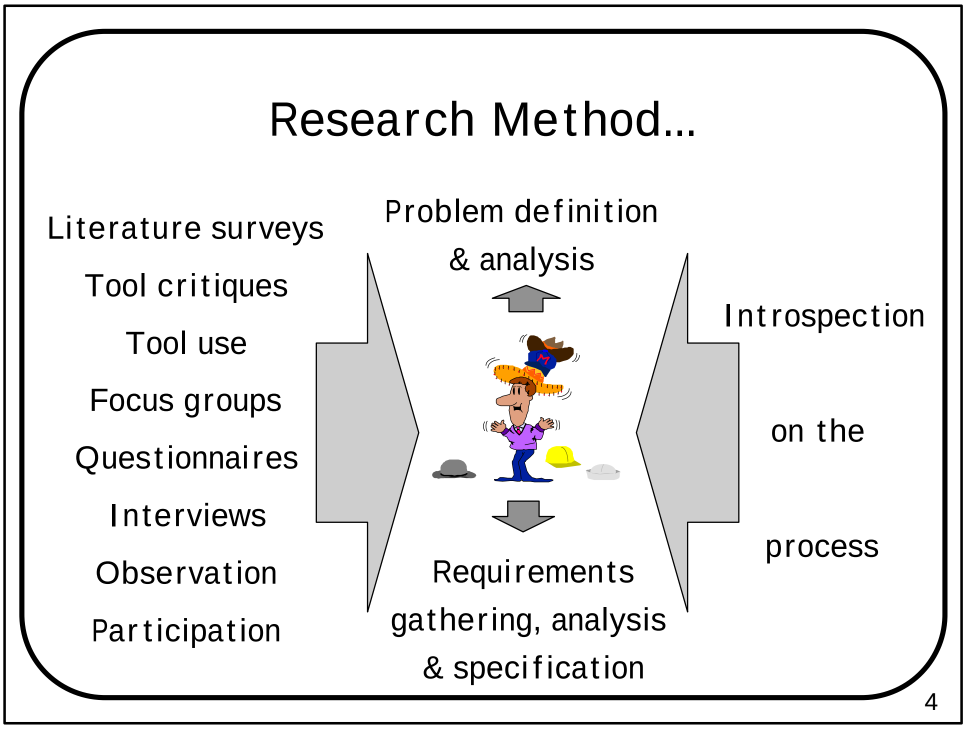
❷ Current support

❸ Persistent RT problems

❹ Types of RT

❺ Longer term issues

❻ Crux of the problem



Research Method...

Literature surveys
Tool critiques
Tool use
Focus groups
Questionnaires
Interviews
Observation
Participation

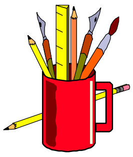
Problem definition & analysis

Requirements gathering, analysis & specification

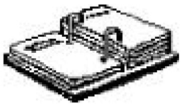
Introspection on the process

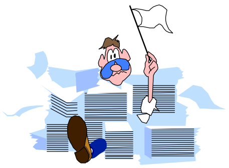
Current Support - Mechanics...

- Explicit techniques:
  - ☞ Cross reference schemes / Matrices
  - ☞ Templates / Documents
  - ☞ ATMS / Constraint networks



- Implicit approcahes:
  - ☞ Languages
  - ☞ Models
  - ☞ Methods

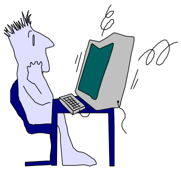


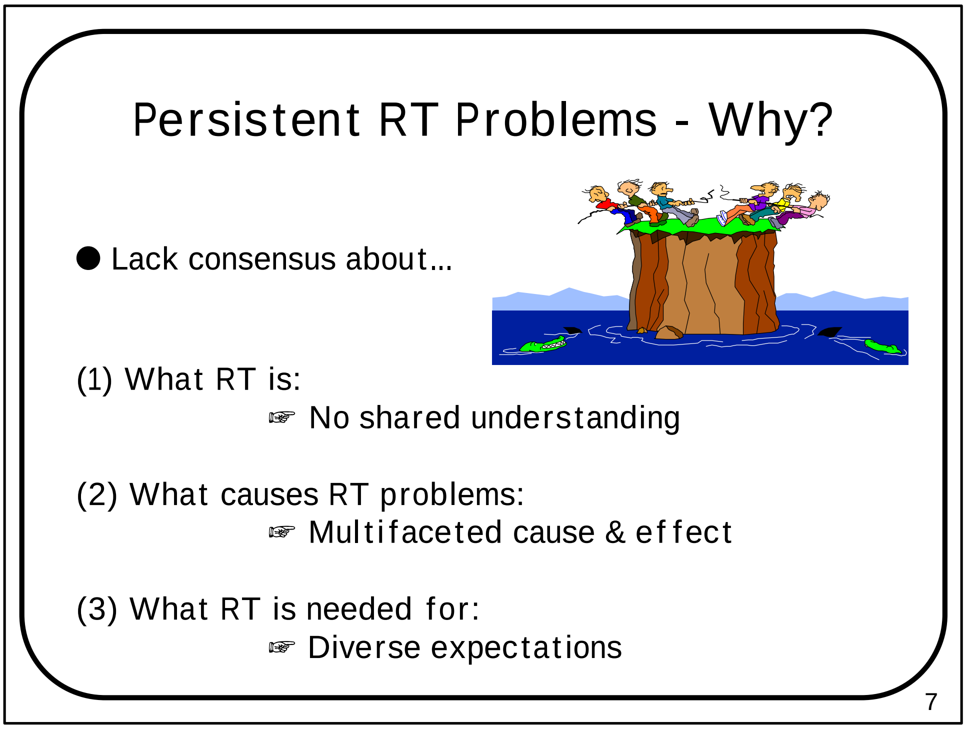


Current Support - Tools...

- General purpose tools
- Special purpose tools

- Workbenches:
  - ☞ Dedicated to requirements
  - ☞ Conventional upper & lower CASE
- Environments (& beyond):
  - ☞ Language-based
  - ☞ Structure-based
  - ☞ Method-based
  - ☞ Toolkit-based





Persistent RT Problems - Why?

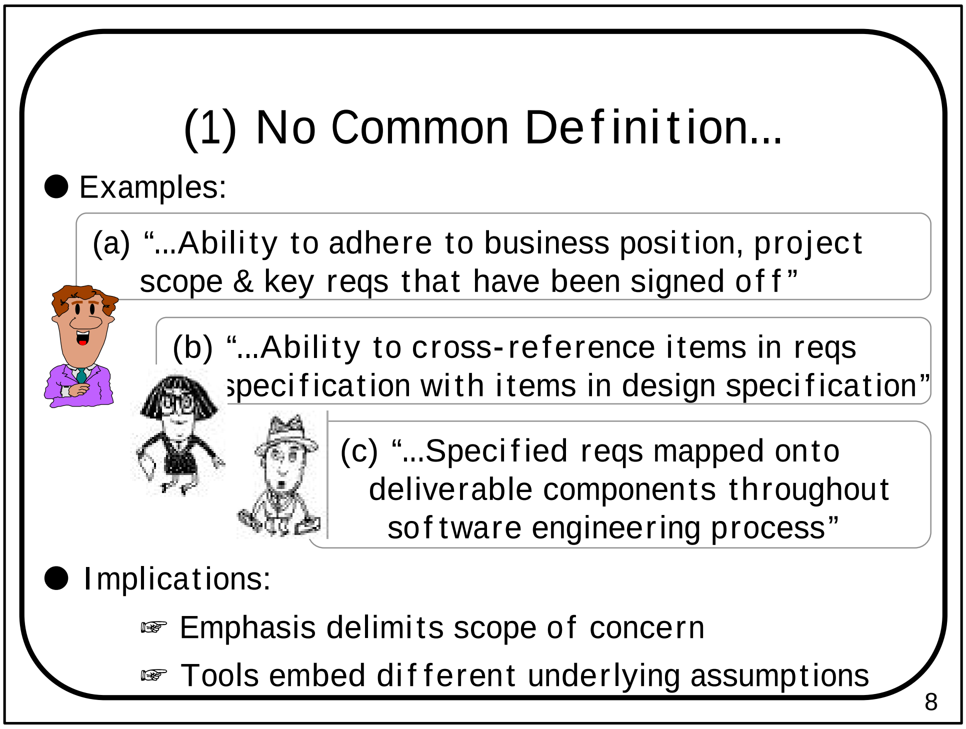
- Lack consensus about...

(1) What RT is:
☞ No shared understanding

(2) What causes RT problems:
☞ Multifaceted cause & effect

(3) What RT is needed for:
☞ Diverse expectations

7



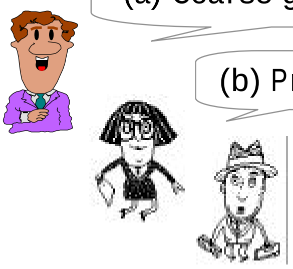
(1) No Common Definition...

- Examples:
  - (a) "...Ability to adhere to business position, project scope & key reqs that have been signed off"
  - (b) "...Ability to cross-reference items in reqs specification with items in design specification"
  - (c) "...Specified reqs mapped onto deliverable components throughout software engineering process"
- Implications:
  ☞ Emphasis delimits scope of concern
  ☞ Tools embed different underlying assumptions

8

(2) Multiple Problem Causes...

- Examples:



(a) Coarse granularity of traceable entities

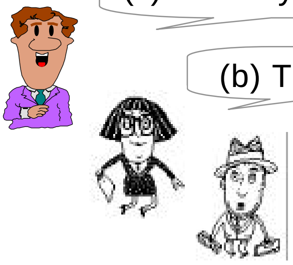
(b) Project longevity

(c) Lack of commitment by all parties

- Implications:
  - ☞ Problem statement ambiguity
  - ☞ Tools address different underlying problems

(3) Numerous Expectations...

- Examples:

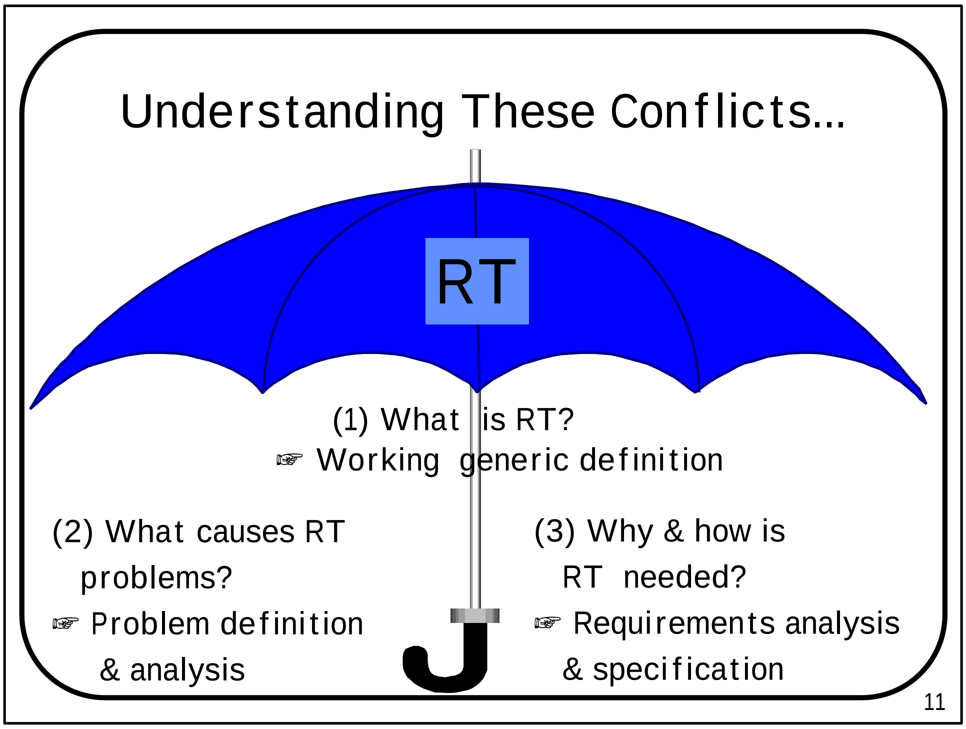


(a) To analyse consistency & completeness

(b) To assess change impact

(c) To see requirements from multiple viewpoints

- Implications:
  - ☞ Unclear (user) requirements for RT
  - ☞ Limitations on what RT can achieve



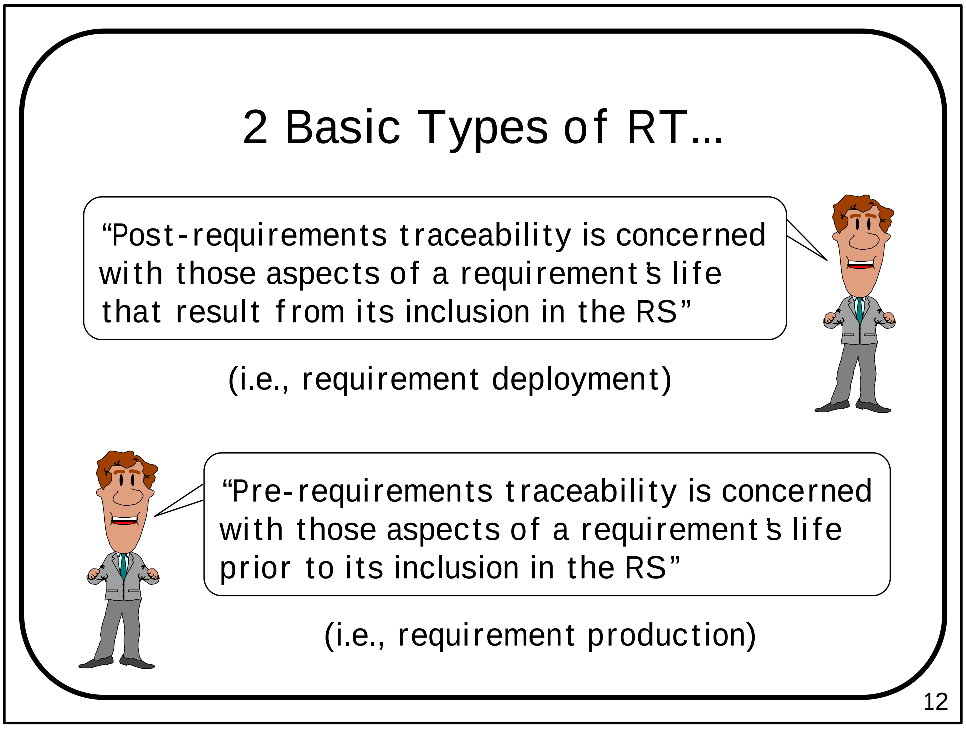
Understanding These Conflicts…

RT

(1) What is RT?
☞ Working generic definition

(2) What causes RT problems?
☞ Problem definition & analysis

(3) Why & how is RT needed?
☞ Requirements analysis & specification



2 Basic Types of RT…

"Post-requirements traceability is concerned with those aspects of a requirement's life that result from its inclusion in the RS"

(i.e., requirement deployment)

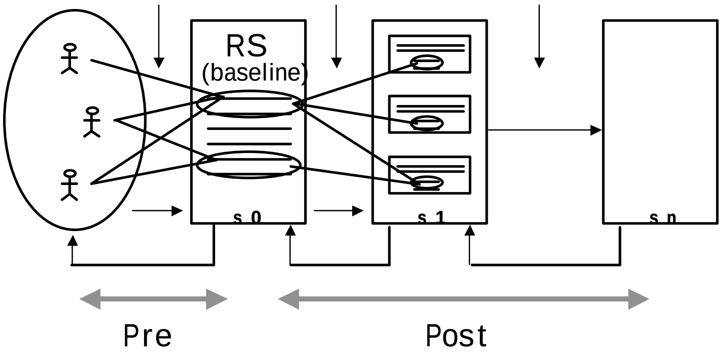
"Pre-requirements traceability is concerned with those aspects of a requirement's life prior to its inclusion in the RS"

(i.e., requirement production)

Pre & Post-Reqs Traceability…

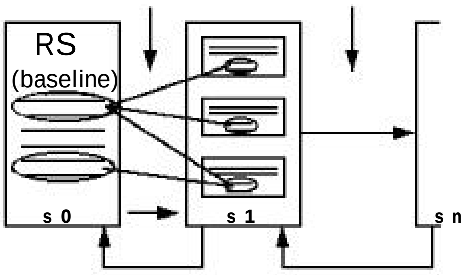
Reqs artifacts produced
(related to production)

Reqs artifacts produced
(related to deployment)



Post-Reqs Traceability…

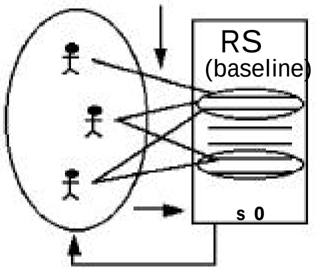
Intermediate artifacts



- Well understood & supported
- Remaining problems tackled in formal settings
- Limited impact on reducing problems

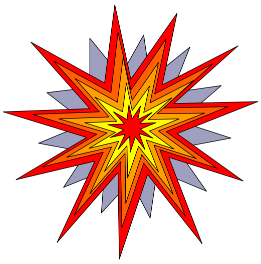
Pre-Reqs Traceability...

Intermediate artifacts



- ● Poorly understood & supported
- ● Only contributor to problems in formal settings
- ● Instrumental in reducing long term problems

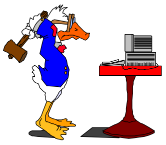
Work Tackling Pre-Reqs Issues...



- ● Awareness of requirements:
  - ☞ Frameworks & activity models / Common threads of involvement
- ● Obtaining & recording:
  - ☞ RE tools / Exploratory workbenches
- ● Organising & maintaining:
  - ☞ Requirements as modular viable systems / Roles
- ● Accessing & representing:
  - ☞ Programmability / Context-sensitive dynamic traces

But - RT Reqs Are Situated...

Comprehensive & up to date project information + Sophisticated retrieval & presentation ≠ No RT problems



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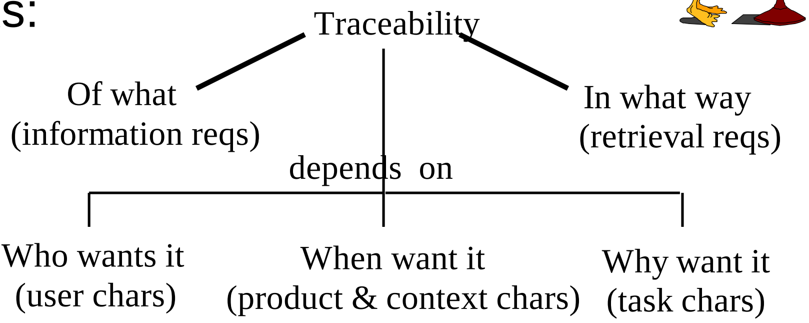


Traceability

Of what (information reqs)

In what way (retrieval reqs)

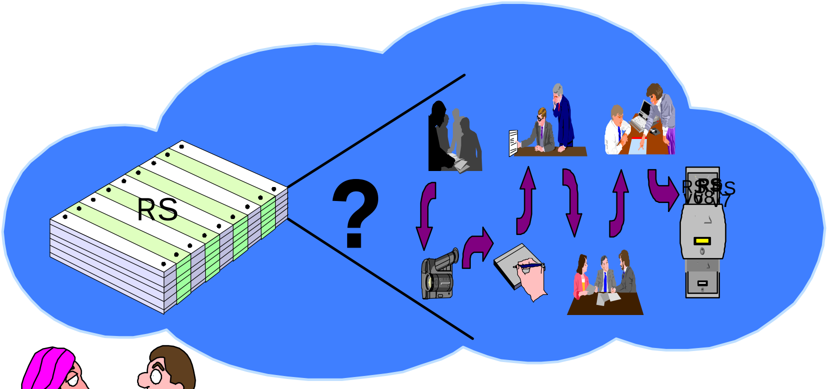
depends on

Who wants it (user chars)

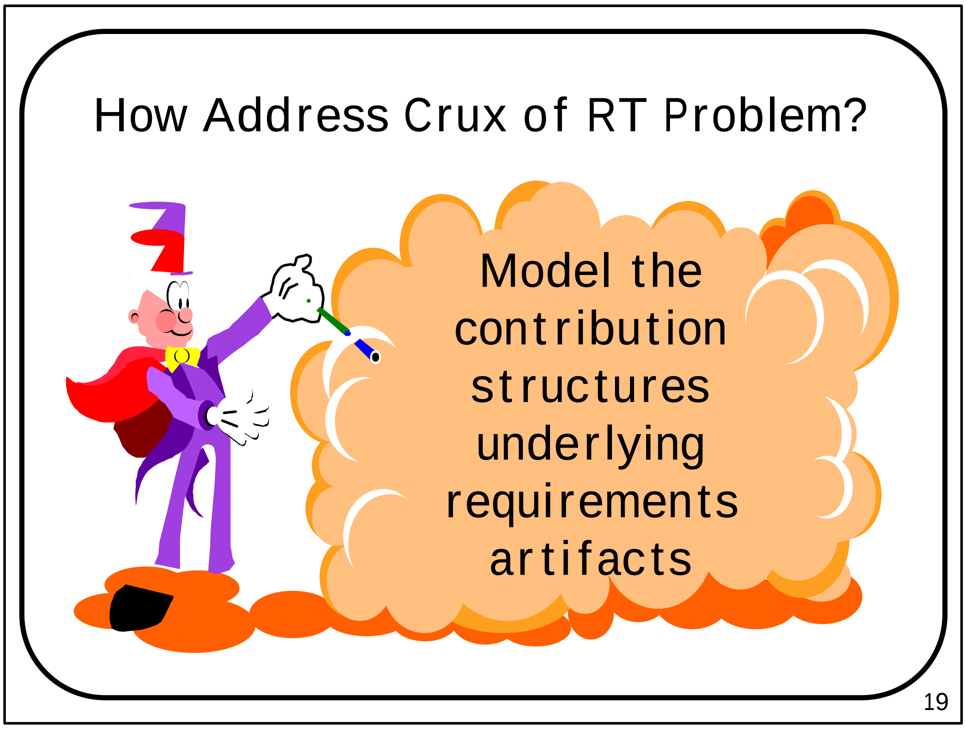
When want it (product & context chars)

Why want it (task chars)

A Fundamental Working Practice Is...

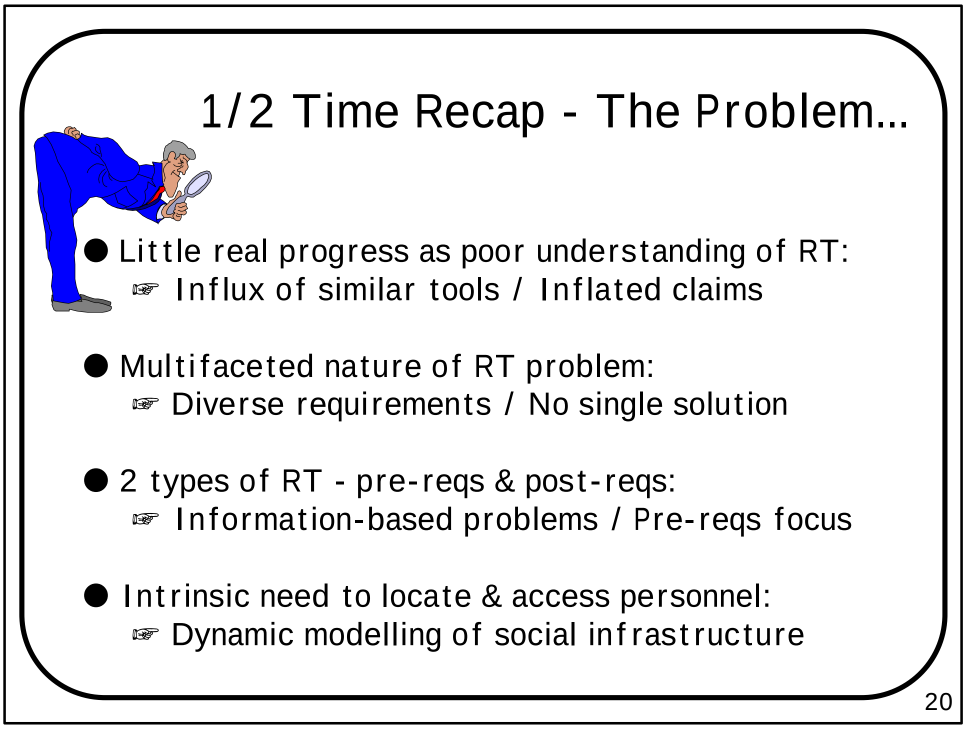


- ● Location & access of personnel
  - ☞ To back up / To augment



How Address Crux of RT Problem?

Model the contribution structures underlying requirements artifacts



1/2 Time Recap - The Problem...

- Little real progress as poor understanding of RT:
  - ☞ Influx of similar tools / Inflated claims
- Multifaceted nature of RT problem:
  - ☞ Diverse requirements / No single solution
- 2 types of RT - pre-reqs & post-reqs:
  - ☞ Information-based problems / Pre-reqs focus
- Intrinsic need to locate & access personnel:
  - ☞ Dynamic modelling of social infrastructure

(b) Modelling Contribution Structures

❶ Outline of the approach

❷ Relating agents & artifacts

❸ Relating artifacts

❹ Roles & commitments

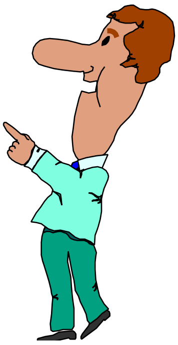
❺ Implementation

❻ Scenario

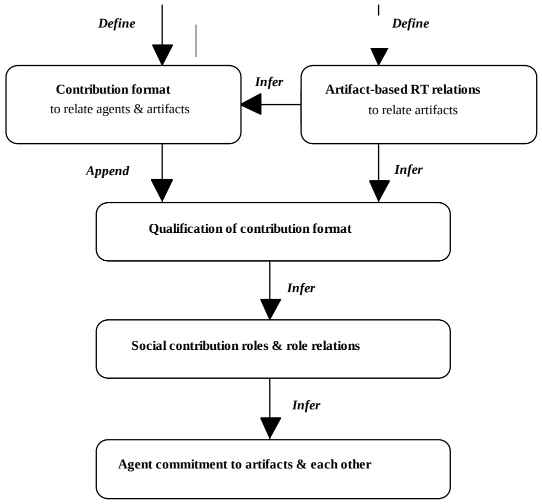
❼ Discussion

Some Preliminaries...

- Social infrastructure
- Scope of concern, problems to address & assumptions
- Requirements:
  - ☞ Differentiate how agents contribute
  - ☞ Account for artifact-based relations
  - ☞ Basis for modelling & reasoning
- Contribution structure
- Insightful areas



Outline of the Approach...



Define

Define

Contribution format
to relate agents & artifacts

Infer

Artifact-based RT relations
to relate artifacts

Append

Infer

Qualification of contribution format

Infer

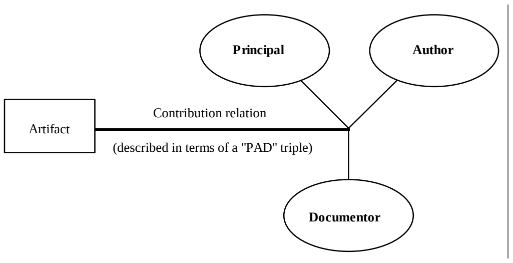
Social contribution roles & role relations

Infer

Agent commitment to artifacts & each other

Relating Agents & Artifacts...

- Goffman's "participant roles" ➜ Contribution format



Principal

Author

Artifact

Contribution relation

(described in terms of a "PAD" triple)

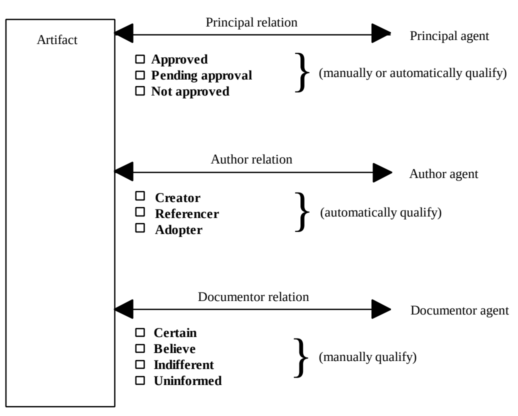
Documentor

P: agent whose position/belief is established

A: agent who formulated/organised content & structure

D: agent who recorded or transcribed

Qualifying Contribution Relations…



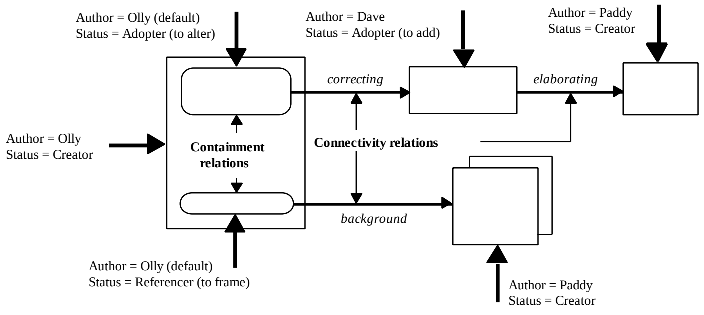
- ● Signatures
- ● Sources
- ● Moods

Relating Artifacts…

① Temporal ② Developmental ③ Auxiliary

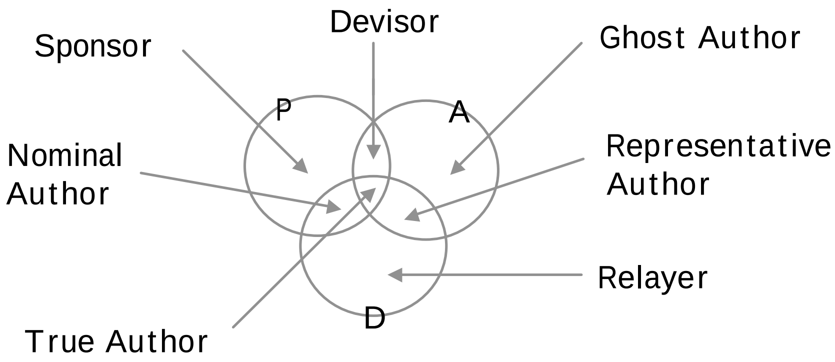
Containment
(layering & nesting)

Connectivity
(cohesion & coherence)

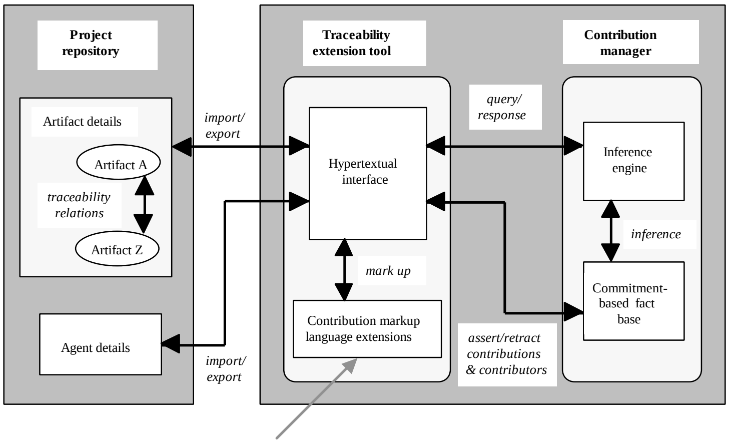


Roles & Commitments...

- Individual & collective commitment to artifacts
- Social commitment to each other - role relations



Implementation...



<CP=[Agent, Qualification]> ... </<CP>
<REL=[Source, Target, Function, Purpose]>
etc.....

Part of the Underlying Model...

Basic types :
[AGENT]
[ARTIFACT]

Data type definitions :
CAPACITY ::= Principal | Author | Documentor
RELATION ::= Contains | References | Adopts
QUALIFICATION ::= PQUALIF | AQUALIF | DQUALIF
PQUALIF ::= Approved | Pendingapproval | Notapproved
AQUALIF ::= Creator | Referencer | Adopter
DQUALIF ::= Certain | Believe | Indifferent | Uninformed
PURPOSE ::= CPURPOSE | RPURPOSE | APURPOSE
CPURPOSE ::= Component
RPURPOSE ::= Frame | Match | Substantiate | Causal
APURPOSE ::= Copy | Add | Remove | Alter

Derived sets:
REGISTERED_AGENT: P AGENT
REGISTERED_ARTIFACT: P ARTIFACT
GROUP_AGENT: P (AGENT X P AGENT)
CONTRIBUTION_RELATION: P (AGENT X ARTIFACT X CAPACITY X QUALIFICATION)
ARTIFACT_RELATION: P (ARTIFACT X ARTIFACT X RELATION X PURPOSE)

State:
REGISTERED_AGENT U REGISTERED_ARTIFACT U GROUP_AGENT U CONTRIBUTION_RELATION U ARTIFACT_RELATION

Some Things Made Possible...

all_agents_and_their_contributions : P (AGENT X P ARTIFACT)
== {ag : AGENT; art_ list: setARTIFACT | ∀art : ARTIFACT • art ∈ art_ list ⇒ is_ contributor_ to (art , ag)}

agent_collaborates_on_artifacts_with(ag) : AGENT --> P AGENT
== {ag_ list: setAGENT | ∀ a : AGENT • a ∈ ag_ list ⇒ (ag_ contributions (ag) ∩ ag_ contributions (a)) ≠ ∅}

agent_has_related_agents(ag) : AGENT --> P AGENT
== ag_ collabs_ on_ arts_ with (ag) ∪ ag_ group_ membs (ag) ∪ ag_ membs_ of(ag) ∪ ag_ membs_ with (ag)

mediating_artifact(art1, art2) : ARTIFACT X ARTIFACT--> BOOLEAN
=> (((art_related_ arts_ thro_ in_relations (art 1) ∩ art_related_ arts_ thro_ out_relations (art 2)) ≠ ∅) ∨
((art_related_ arts_ thro_ in_relations (art 2) ∩ art_related_ arts_ thro_ out_relations (art 1)) ≠ ∅))

mediating_agent(art1, art2) : ARTIFACT X ARTIFACT--> BOOLEAN
=> (∃ art 3 : ARTIFACT s. t. mediating_ artifact (art 1, art 2) ∧ (((art_ contributors (art 1) ∩
art_ contributors (art 3)) ≠ ∅) ∧ ((art_ contributors (art 2) ∩ art_ contributors (art 3)) ≠ ∅))

contributors_to_id_artifacts(ag1, ag2) : AGENT X AGENT --> BOOLEAN
=> agent_ contributions (ag 1) ≡ agent_ contributions (ag 2)

related_to_id_agents(ag1, ag2): AGENT X AGENT --> BOOLEAN
=> contributors_ to_ id_ artifacts (ag 1, ag 2) ∧ members_ of _ id_ groups (ag 1, ag 2)

Consider a Scenario...

A software project began with a wish list, reporting needs from a **user group**, written up by a **scribe** and authorised by a **project leader**. The project leader then held a meeting, of which an audio tape record was made, to discuss the wish list with **stakeholders**. A direct transcript of the meeting was subsequently made by some **secretaries**. From the transcript and wish list, along with other input documents, an initial RS was written by a **group of requirements engineers**. Following circulation to and comments from interested parties, a revised version of the RS was written. In particular, an alteration had been made to the requirement covered by paragraph x, as a result of an email message from the M.D.'s **P.A.** to the project leader. In this message, the **M.D.** passed on a verbal change request she received from **user 1**. The changed version of paragraph x becomes paragraph y in the revised RS. Unfortunately, **member 2** of the requirements engineers introduced an error when carrying out this change, largely because he did not acknowledge the subtlety of the wording in the fragment of the email.

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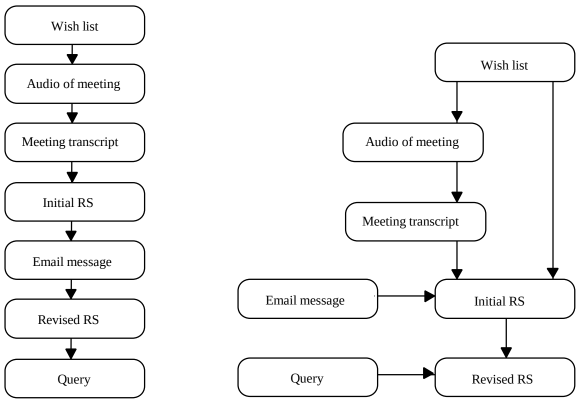
Artifact Chronology & Flow-Down...



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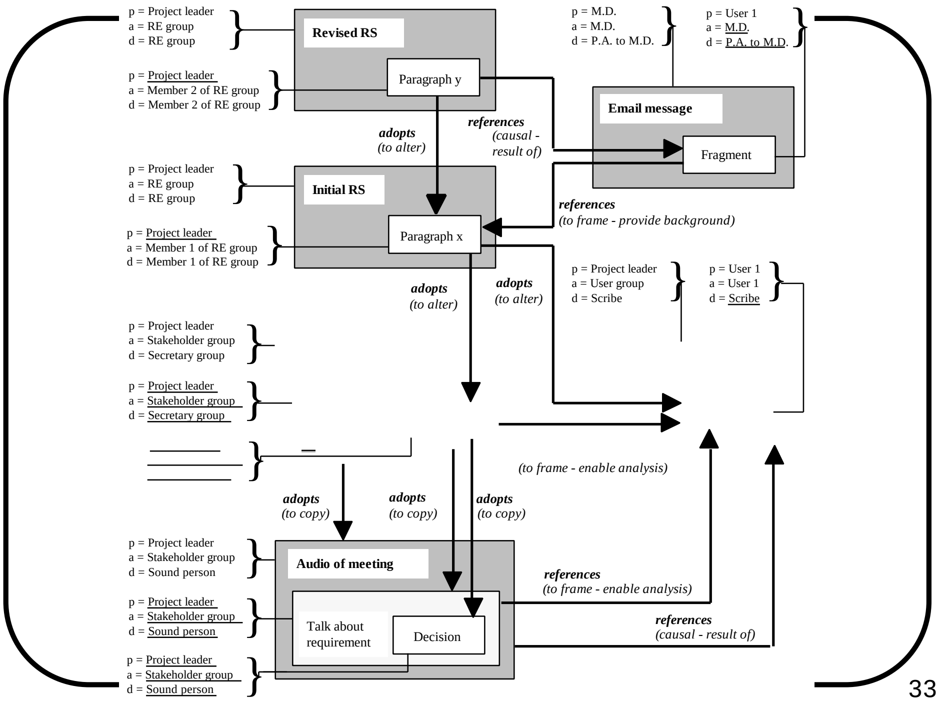


p = Project leader
a = RE group
d = RE group

Revised RS

Paragraph y

p = Project leader
a = Member 2 of RE group
d = Member 2 of RE group

p = M.D.
a = M.D.
d = P.A. to M.D.

p = User 1
a = M.D.
d = P.A. to M.D.

Email message

Fragment

adopts *(to alter)*

references *(causal - result of)*

p = Project leader
a = RE group
d = RE group

Initial RS

Paragraph x

p = Project leader
a = Member 1 of RE group
d = Member 1 of RE group

references *(to frame - provide background)*

adopts *(to alter)*

adopts *(to alter)*

p = Project leader
a = User group
d = Scribe

p = User 1
a = User 1
d = Scribe

p = Project leader
a = Stakeholder group
d = Secretary group

p = Project leader
a = Stakeholder group
d = Secretary group

(to frame - enable analysis)

adopts *(to copy)*

adopts *(to copy)*

adopts *(to copy)*

p = Project leader
a = Stakeholder group
d = Sound person

Audio of meeting

Talk about requirement

Decision

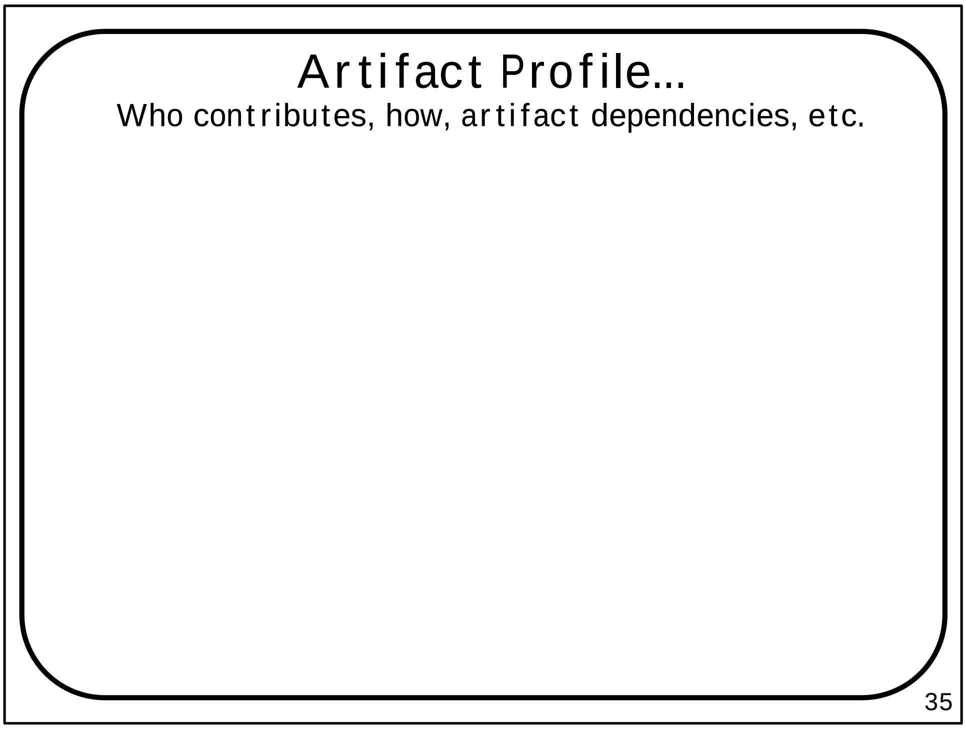
p = Project leader
a = Stakeholder group
d = Sound person

p = Project leader
a = Stakeholder group
d = Sound person

references *(to frame - enable analysis)*

references *(causal - result of)*

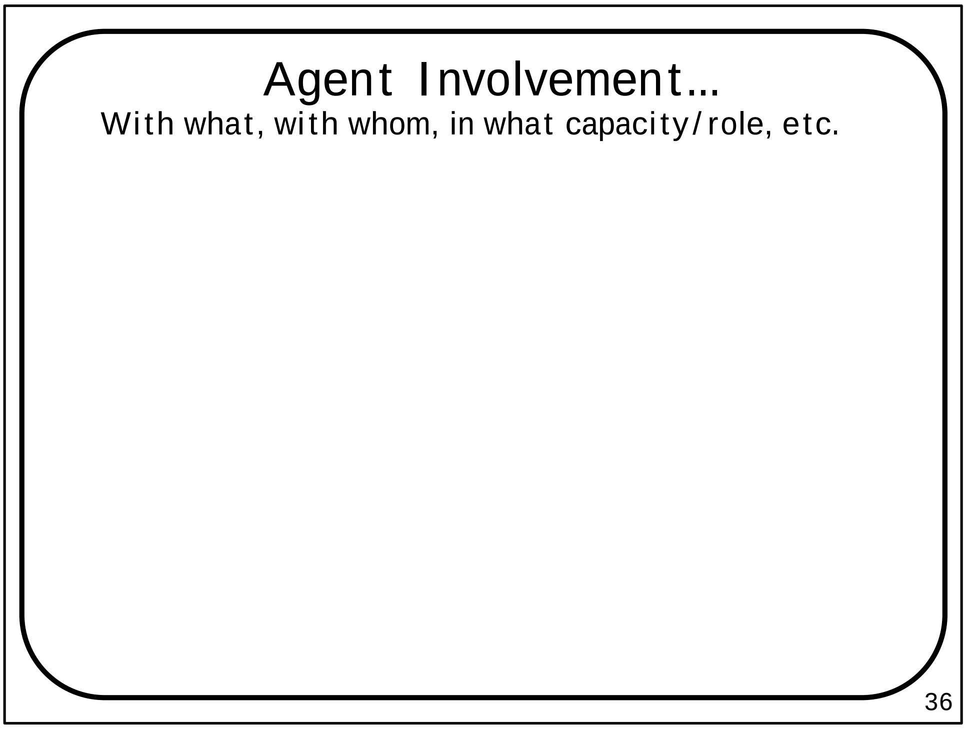
Original Source & Contributors...



Artifact Profile...

Who contributes, how, artifact dependencies, etc.

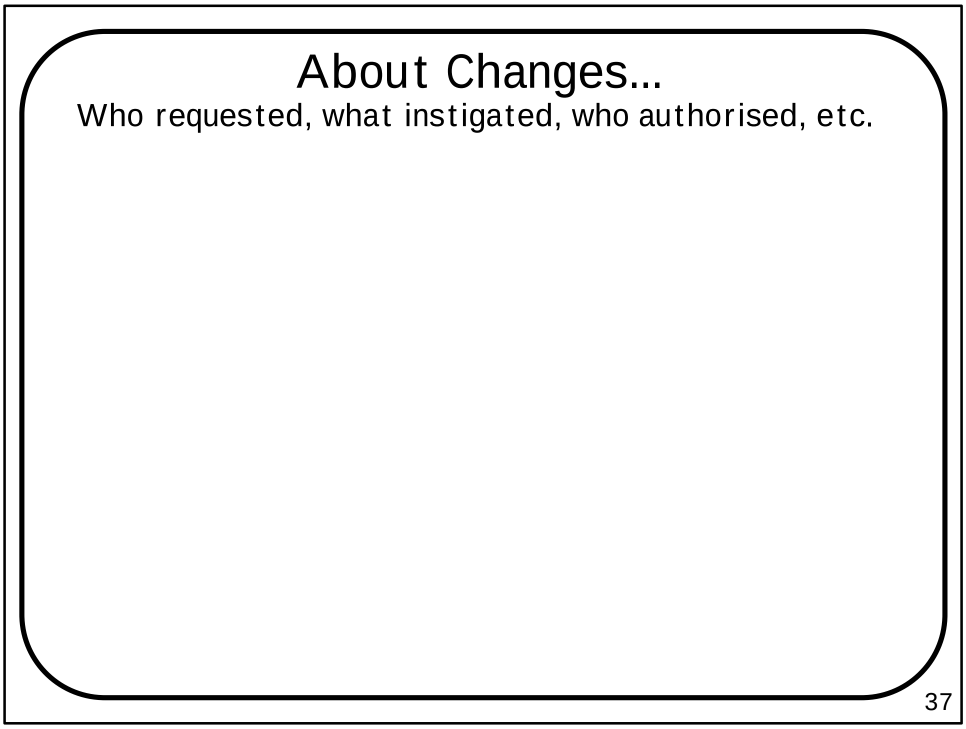
35



Agent Involvement...

With what, with whom, in what capacity/role, etc.

36



About Changes...

Who requested, what instigated, who authorised, etc.

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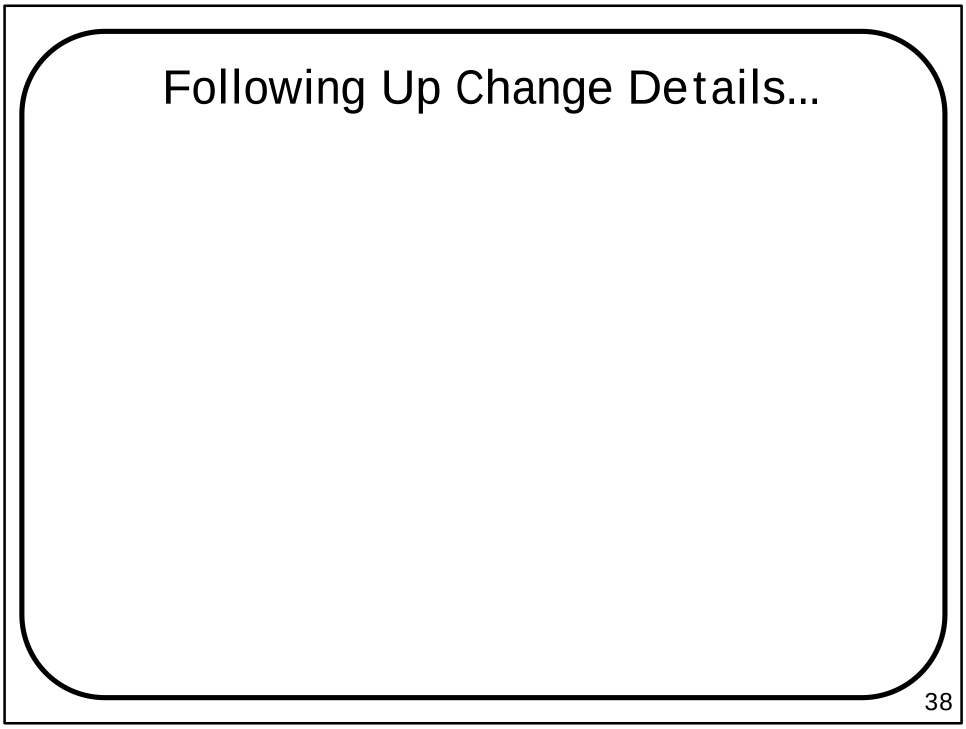

Following Up Change Details...

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Discussion...

Benefits?

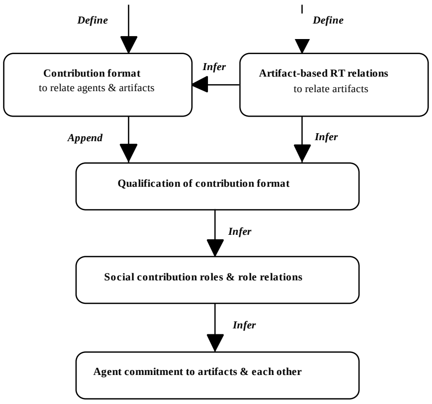
- Deal with:
  - ☞ Info absence
  - ☞ Supplementary info
  - ☞ Human aspects
  - ☞ Continuous change
- Analytic foundations
- Project management
- ...

Issues?

- Automation
- Scaleability
- Firm resistance
- Accountability:
  - ☞ +ve = learn & share
  - ☞ -ve = blame & hide
- Categories
- ...

Full Time Recap - A Solution...

- Crux of RT problem is location & access of personnel
- Model social infrastructure underlying reqs artifacts based on concept of “contribution structures”
- Augments artifact-based RT with contribution structures at each step & uses this info for personnel-based RT + much more...


Define
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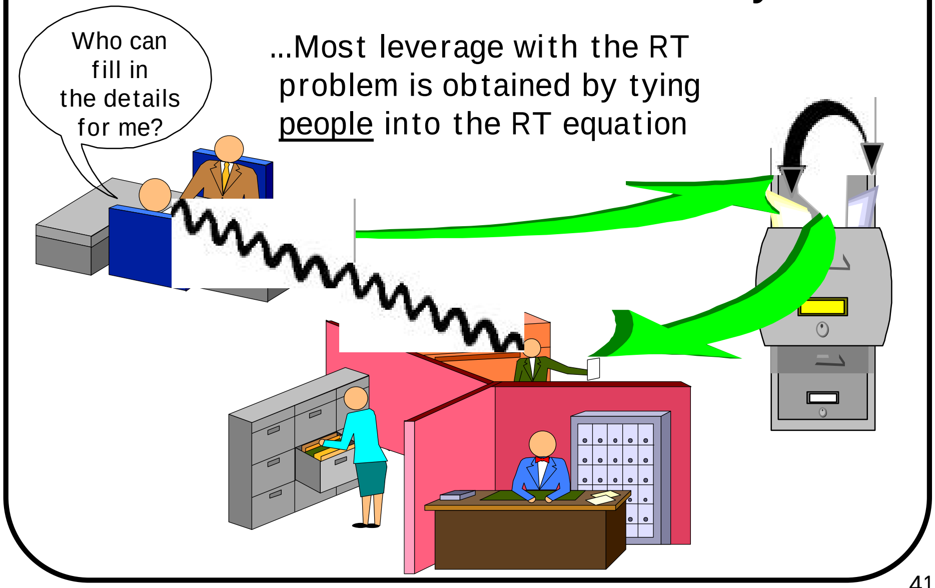
Contribution format
to relate agents & artifacts
Infer
Artifact-based RT relations
to relate artifacts
Append
Infer
Qualification of contribution format
Infer
Social contribution roles & role relations
Infer
Agent commitment to artifacts & each other

The Point To Take Away...

...Most leverage with the RT problem is obtained by tying people into the RT equation



For Further Details...

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Papers can be found at: ftp dse.doc.ic.ac.uk
dse-papers/viewpoints