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Model-Based Testing – From theory to practice

Frédéric Dadeau – Elizabeta Fourneret – Bruno Legeard

Ecole des jeunes chercheurs en programmation – Nancy – 24 june 2015

Presentation of the workshop

Morning - Presentations

- Part I – Introduction to MBT
- Part II – MBT with Smartesting CertifyIt
- Part III – PKCS#11 case study

Afternoon – Practical session

- Discovering ATM case study
- Practicing CertifyIt

femto-st SCIENCES & TECHNOLOGIES

Model-Based Testing – From theory to practice

Part I – Introduction to MBT

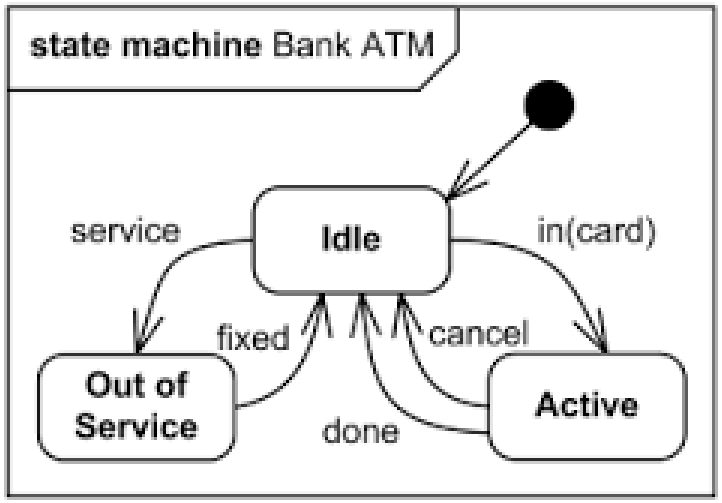
Bruno Legeard

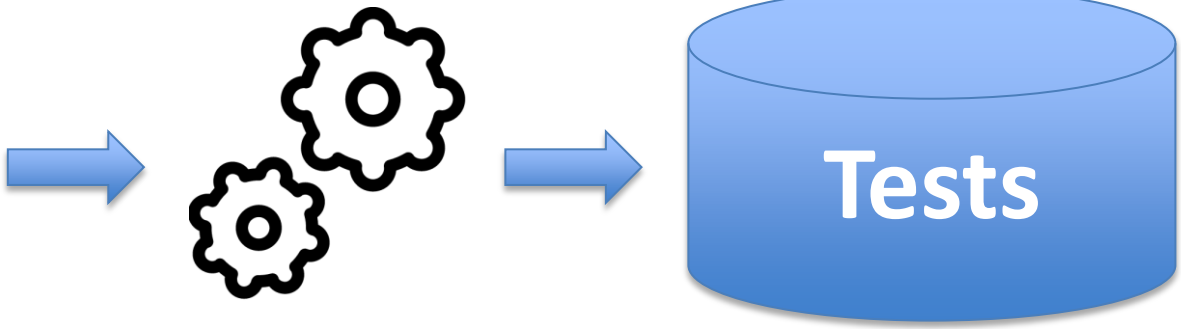
Ecole des jeunes chercheurs en programmation – Nancy – 24 june 2015

400 000 certified testers

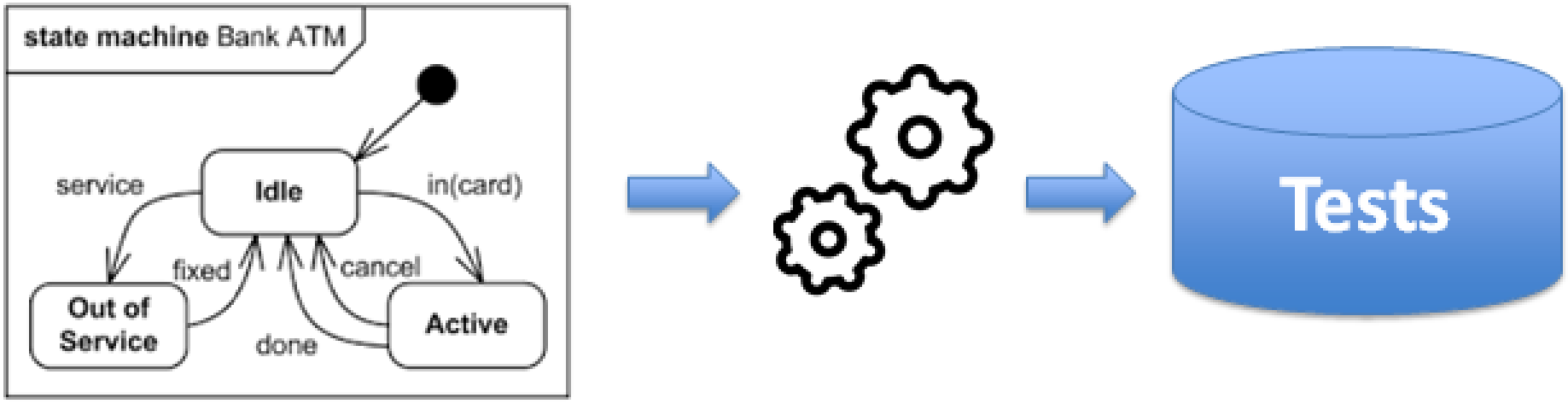
ISTQB Certified Tester

Various faces of MBT





Various faces of MBT



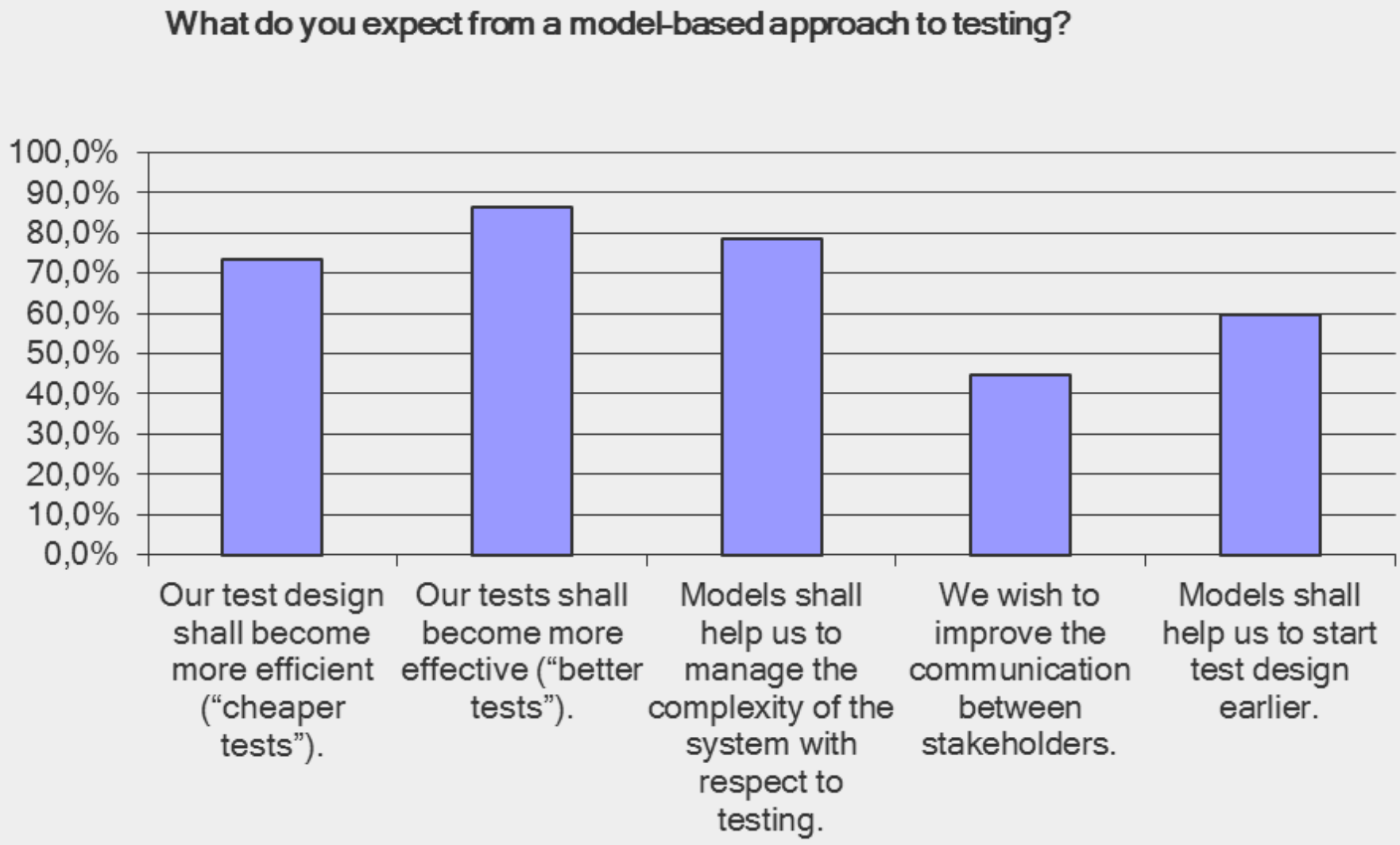
Model-Based Testing : « *Testing based on or involving models.* »

ISTQB Glossary - 2015

Outline

1. Introduction to MBT
    a. Motivations and usage
    b. Process and roles
2. A taxonomy of MBT approaches
3. Application domains
4. Conclusion

Motivations



Source: MBT User Survey 2014

Source : Model-Based Testing, Where do we stand? – CACM – 2/15, Binder, Legeard, Kramer

Motivations

“Test Models provide us more flexibility in the creation of automated test scripts by using different test case generation strategies according to the current needs (different robustness test, tests for changed or critical requirements, etc.)”

“Executable model paradigm should enable us to create self-testing mechanisms.”

“MBT helps us to improve change request process”

“MBT supports test automation”

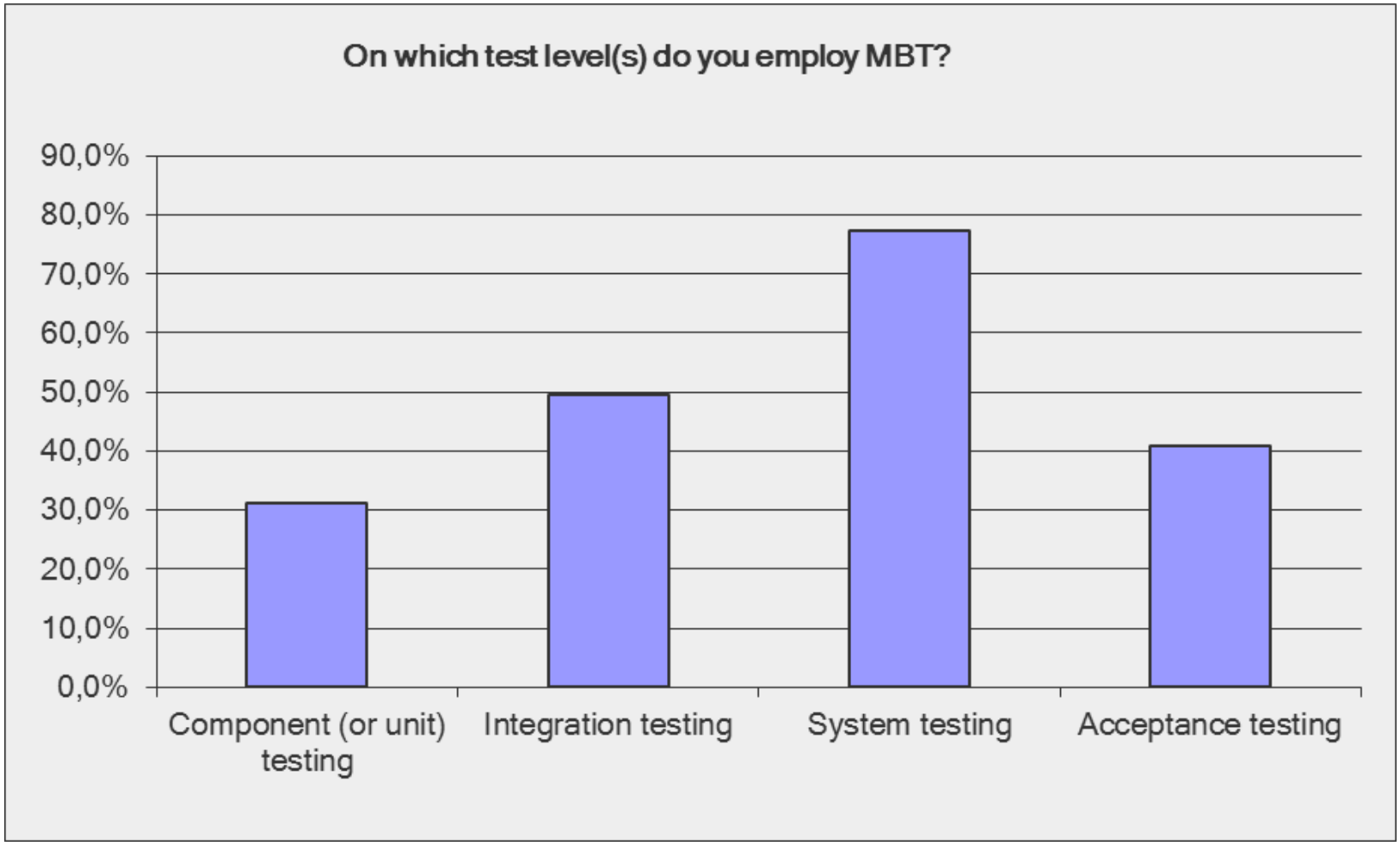
“MBT is capable to also validate the test basis”

“Massive increase of reuse”

“Improved coverage of requirement readability of coverage”

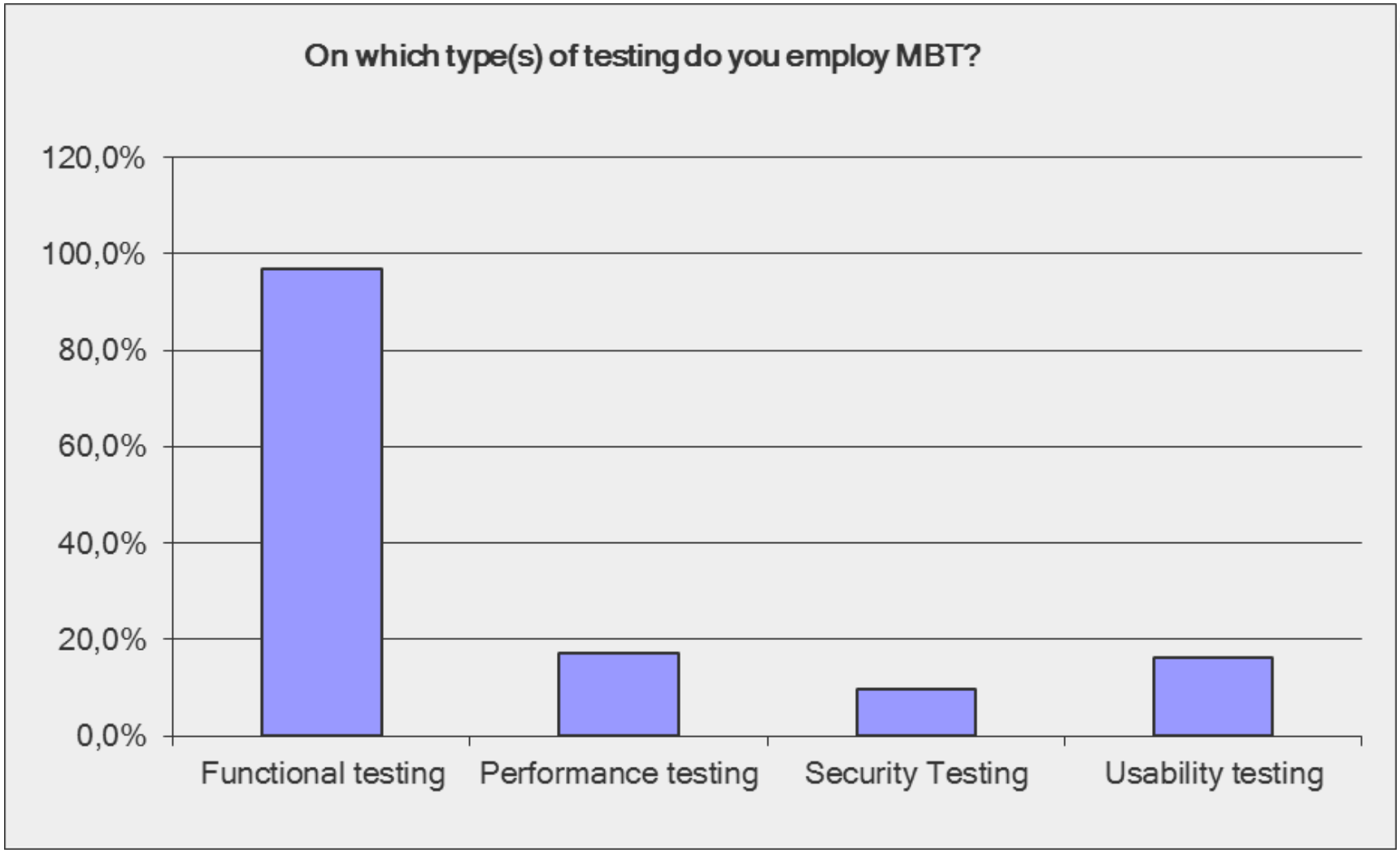
“Increased productivity and improved product reliability (new type of bugs, Increased test coverage)”

Test levels



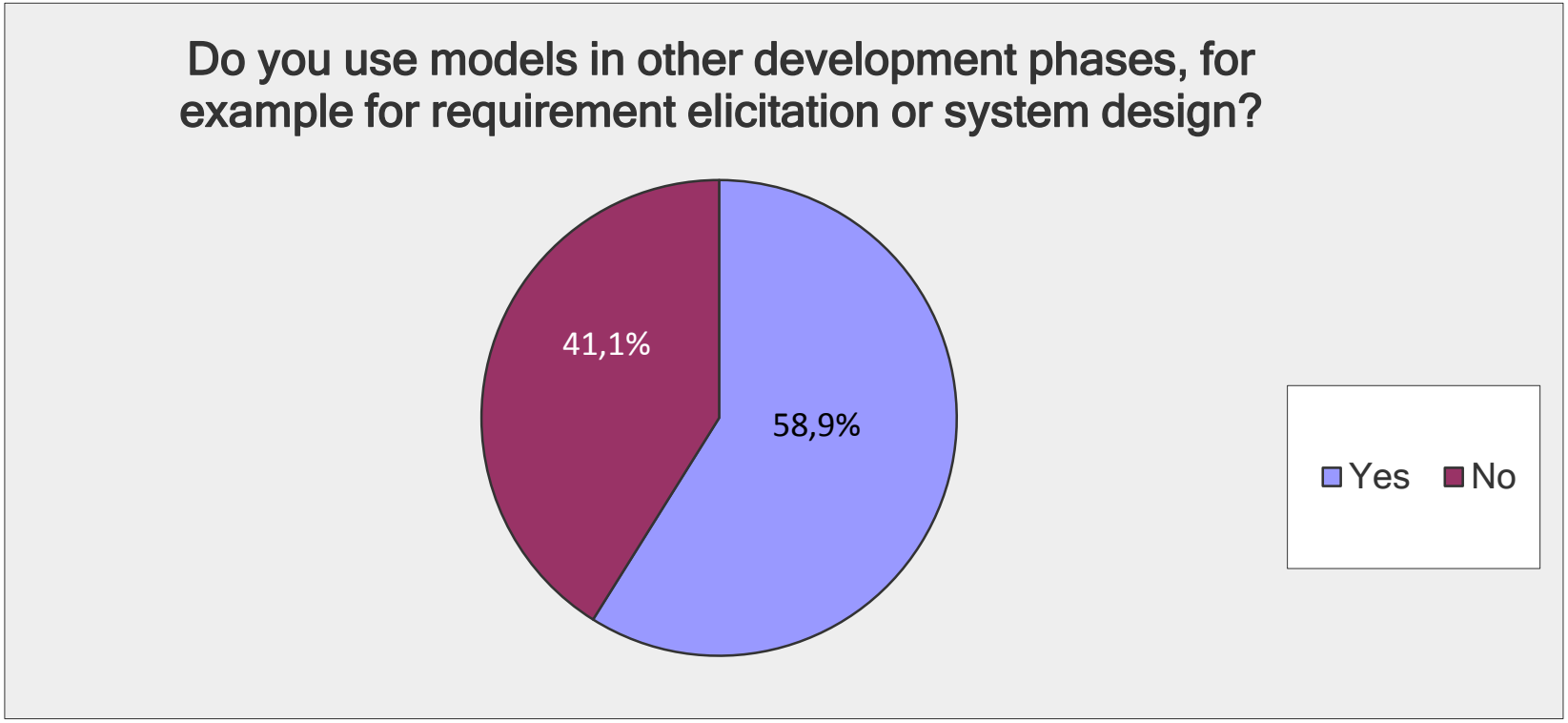
Source: MBT User Survey 2014

Test types



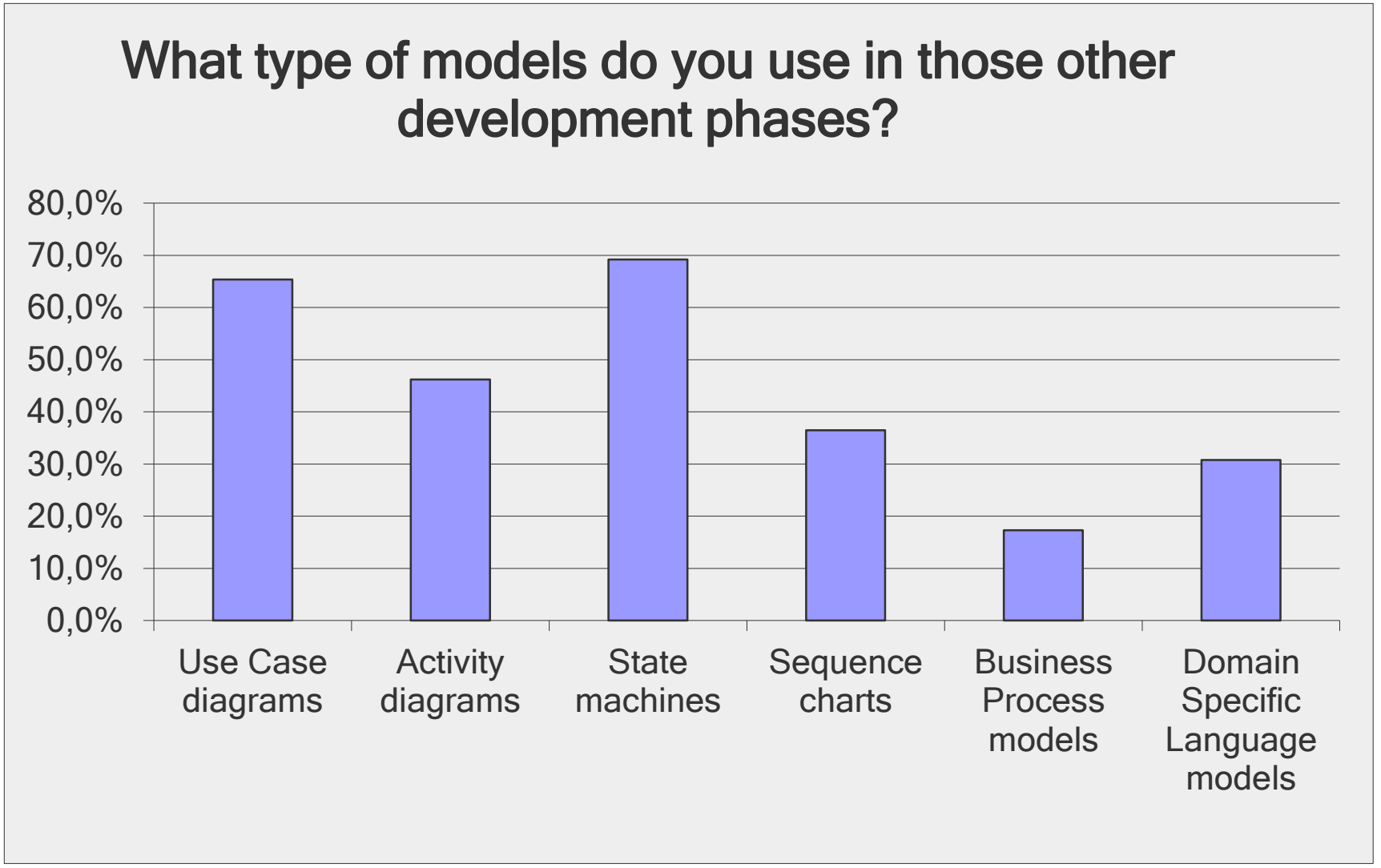
Source: MBT User Survey 2014

Modeling practices



Source: MBT User Survey 2014

Modeling practices - 2



Source: MBT User Survey 2014

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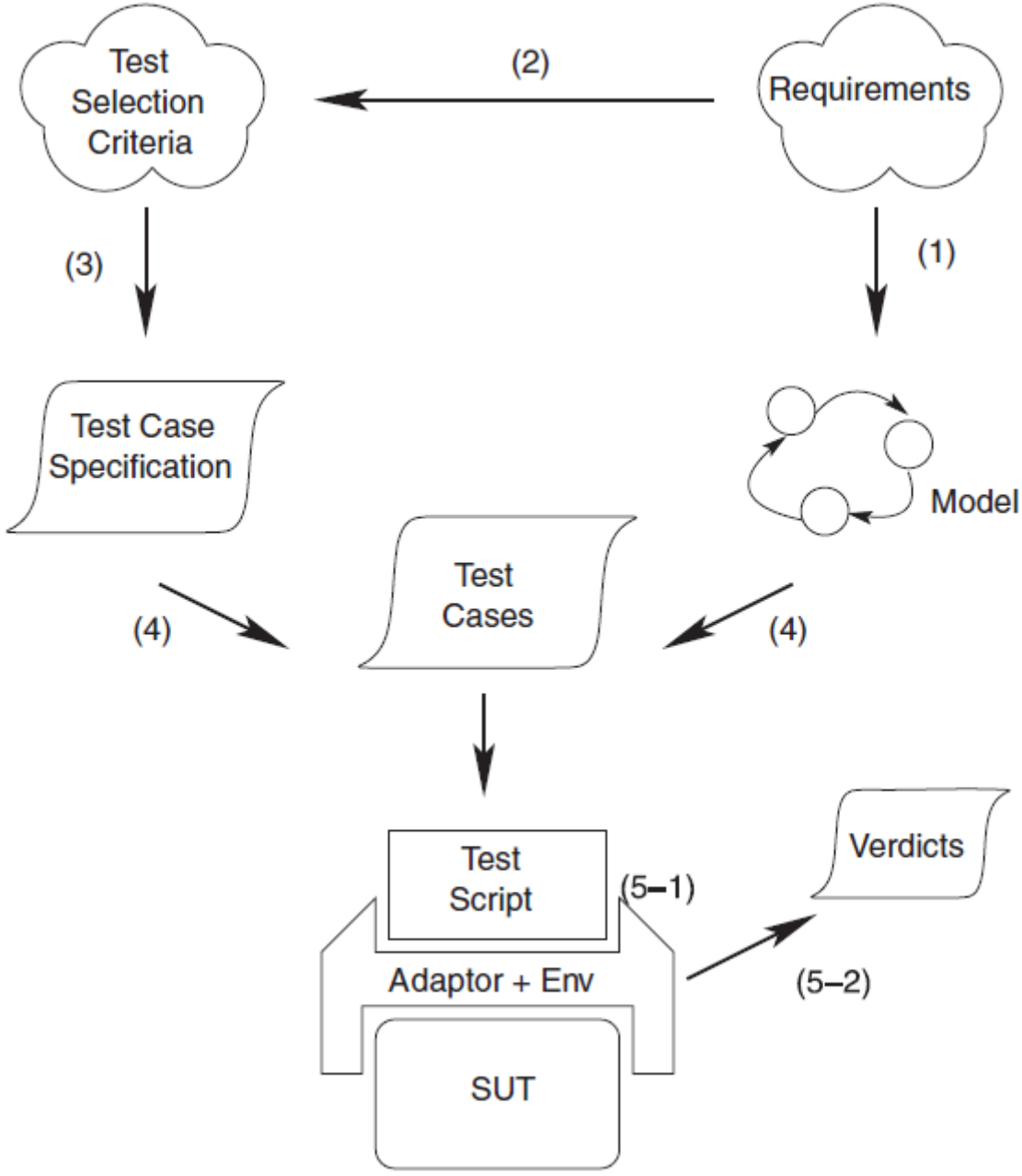
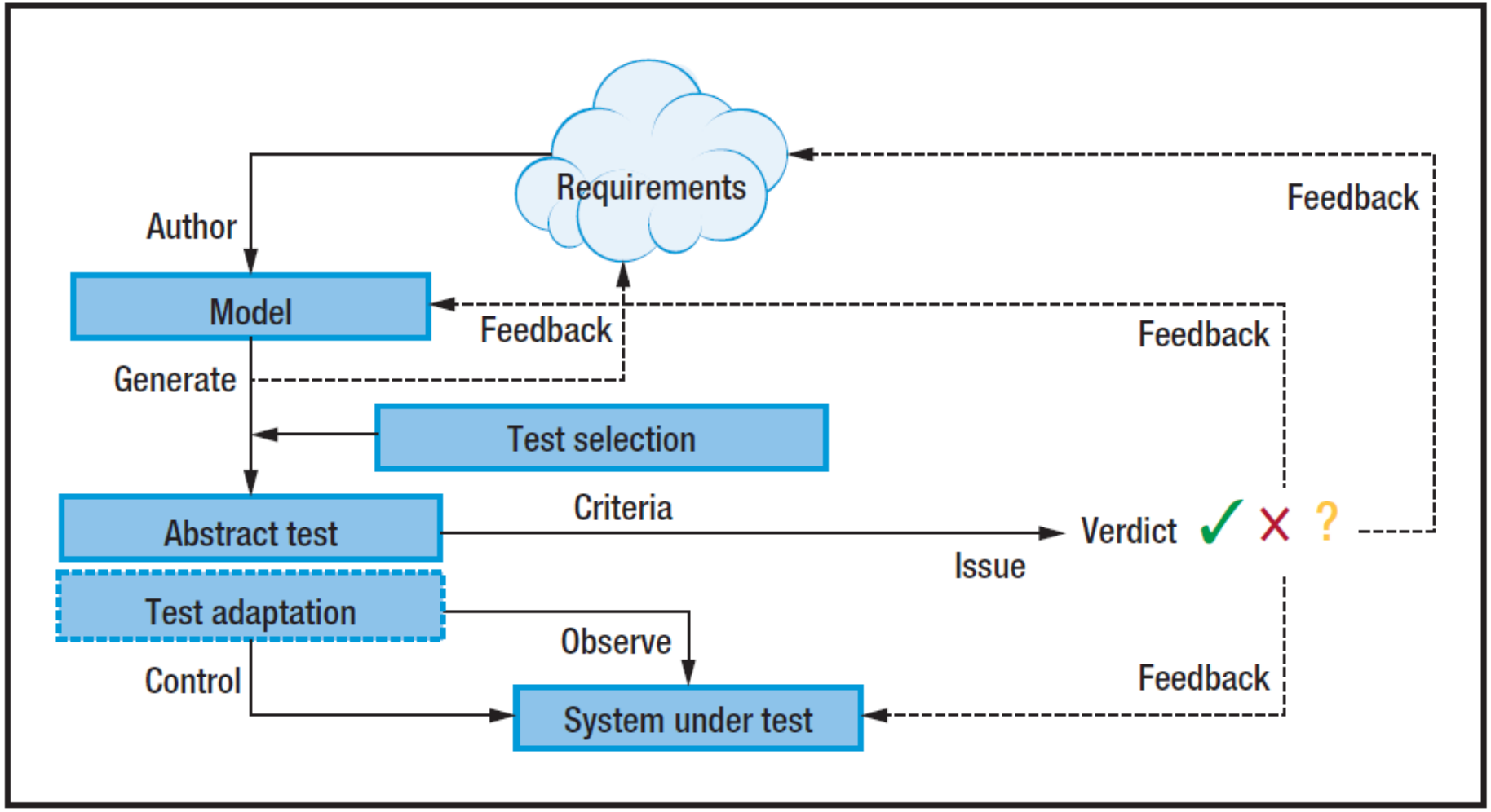
MBT process - 1



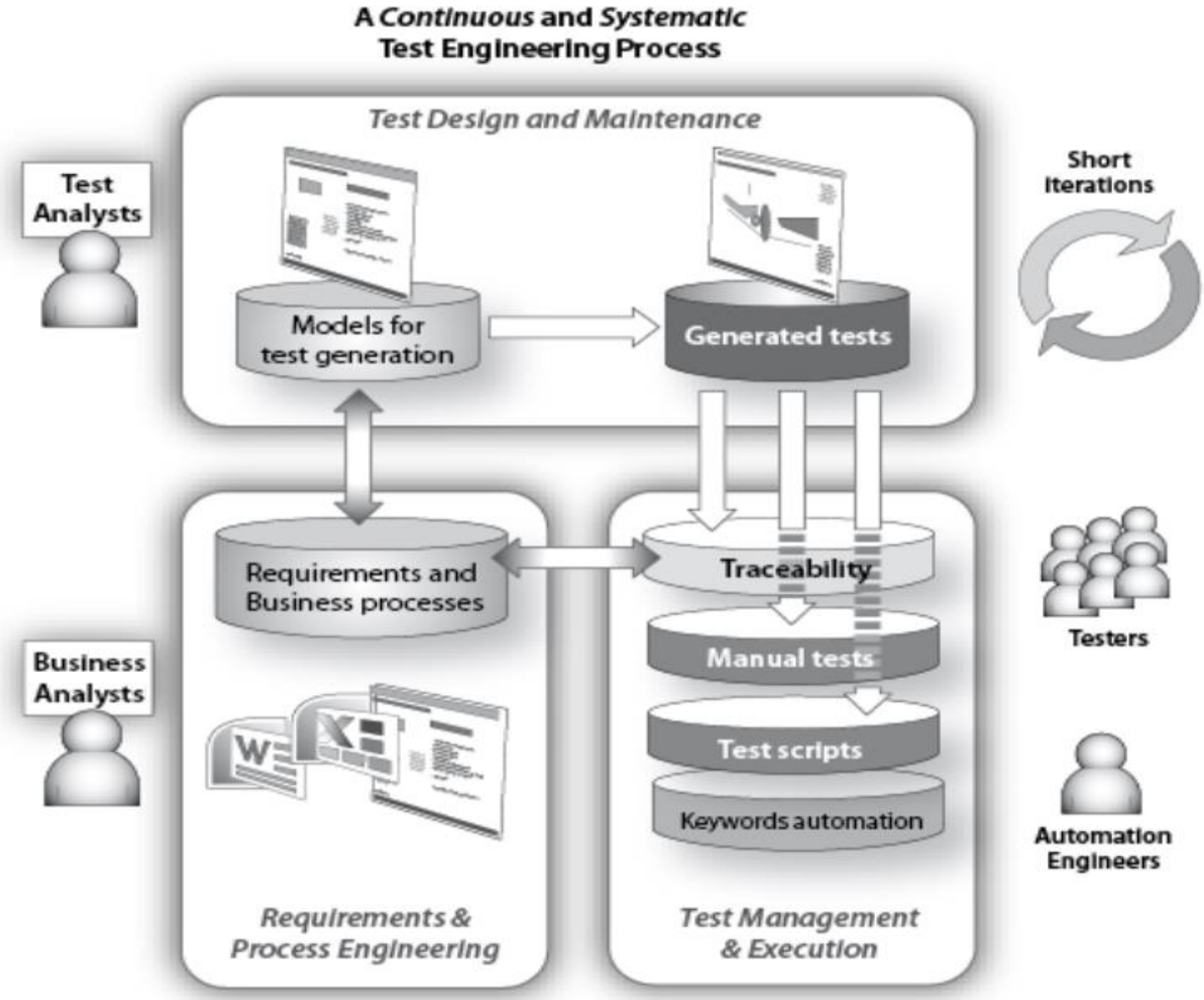
Source : Mark Utting, Alexander Pretschner, and Bruno Legeard. 2012. A taxonomy of model-based testing approaches. *Softw. Test. Verif. Reliab.* 22, 5 (August 2012), 297-312.

MBT Process - 2

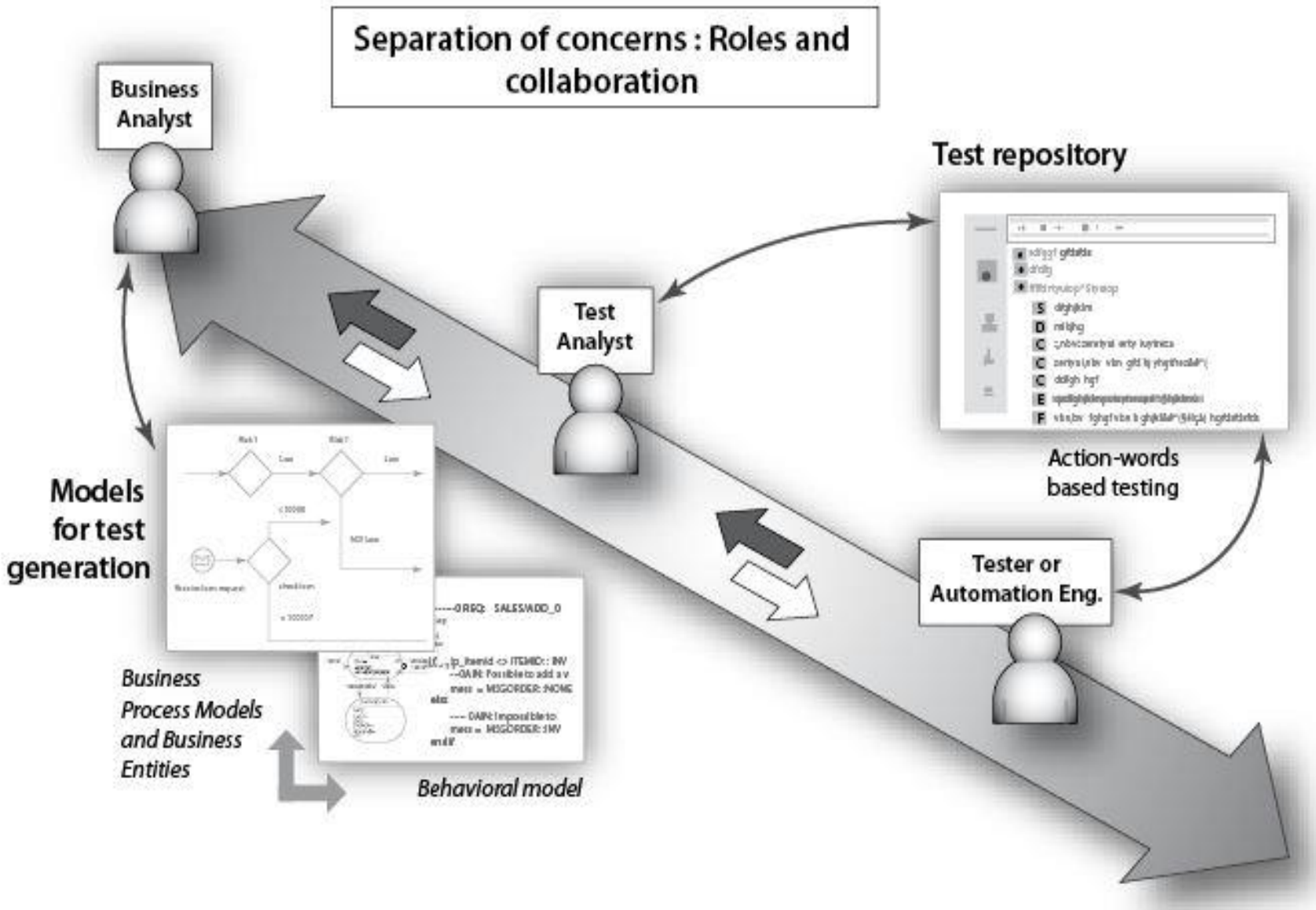


Methods for Testing & Specification (MTS); Model-Based Testing (MBT); Requirements for Modelling Notations, ES 202 951 v 1.1.1, European Telecommunications Standards Inst., 2011.

MBT Process - 3



MBT roles


Separation of concerns : Roles and collaboration
Business Analyst
Test repository
Test Analyst
Models for test generation
Action-words based testing
Tester or Automation Eng.
Business Process Models and Business Entities
Behavioral model

MBT modeling

MBT modeling is strongly related to test objectives.
MBT models should be:

- Abstract enough
  - Covering what is intended to be tested
- Detailled and precise enough
  - Enables to compute the expected results (Oracle)

  ➔ Test verdict assignement
- Validated and verified
  - If the test « fails », what is wrong? The MBT model or the System under Test (SUT)?

  MBT is back-to-back testing – MBT model vs SUT

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2. **A taxonomy of MBT approaches**
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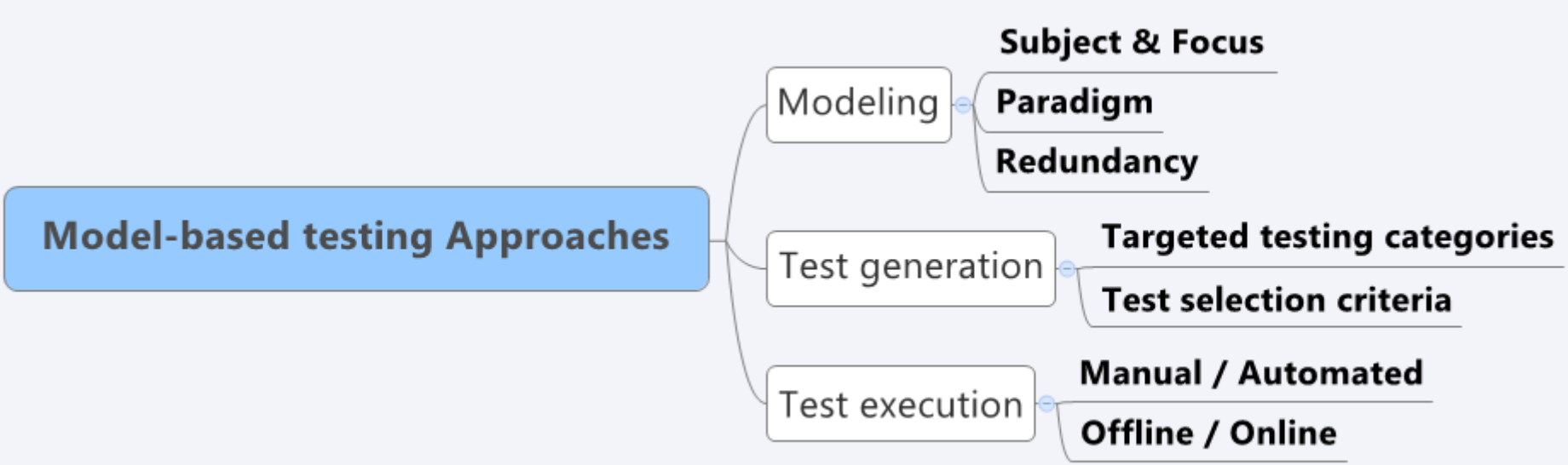
A taxonomy of MBT approaches



Source : Mark Utting, Alexander Pretschner, and Bruno Legeard. 2012. A taxonomy of model-based testing approaches. *Softw. Test. Verif. Reliab.* 22, 5 (August 2012), 297-312.

Subjet and focus of the MBT model

Subjet

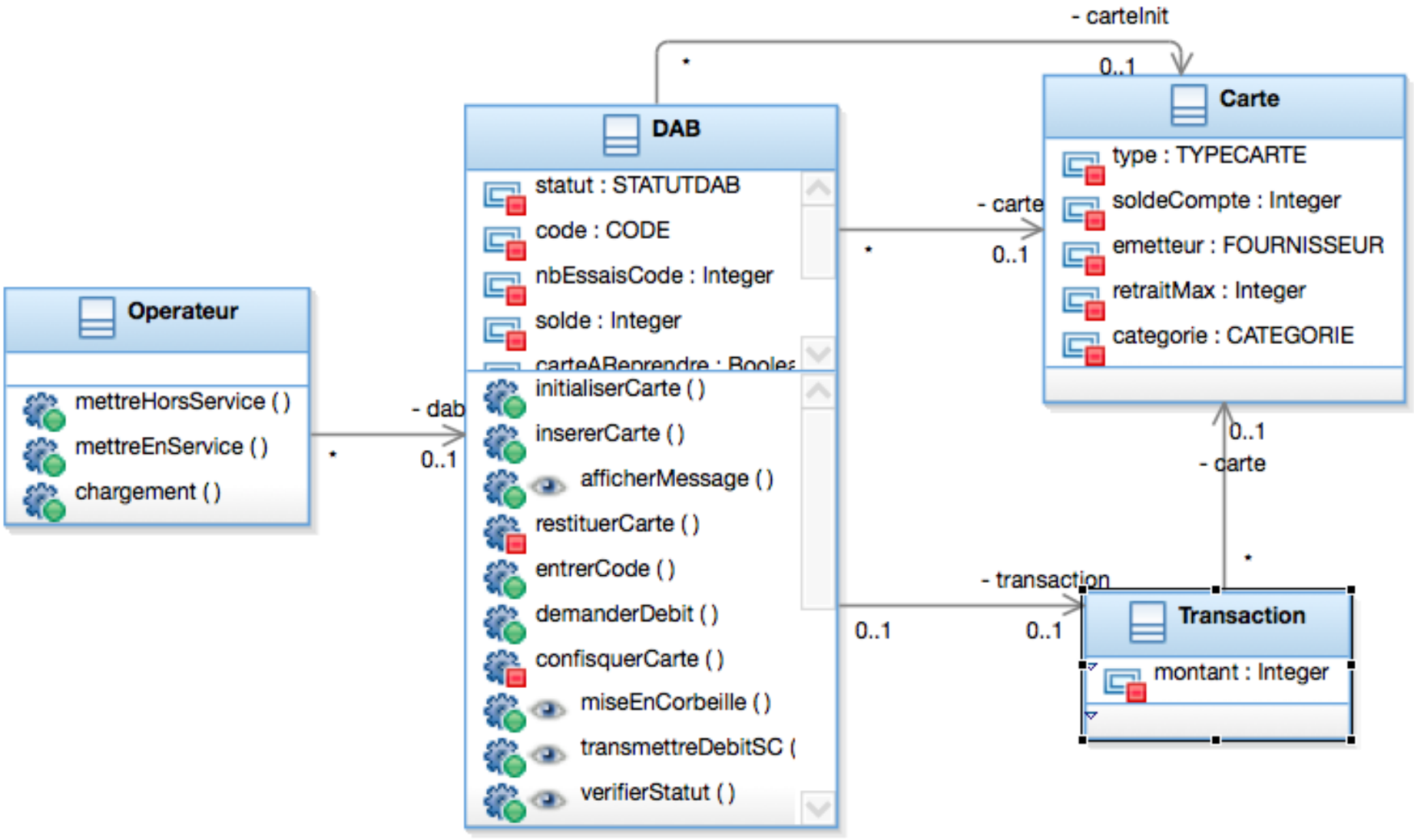
- System
- Environment
- Tests

Focus

- Structure
- Behavior

➔ **An MBT model generally combines these various subject and focus aspects**

MBT model - Example



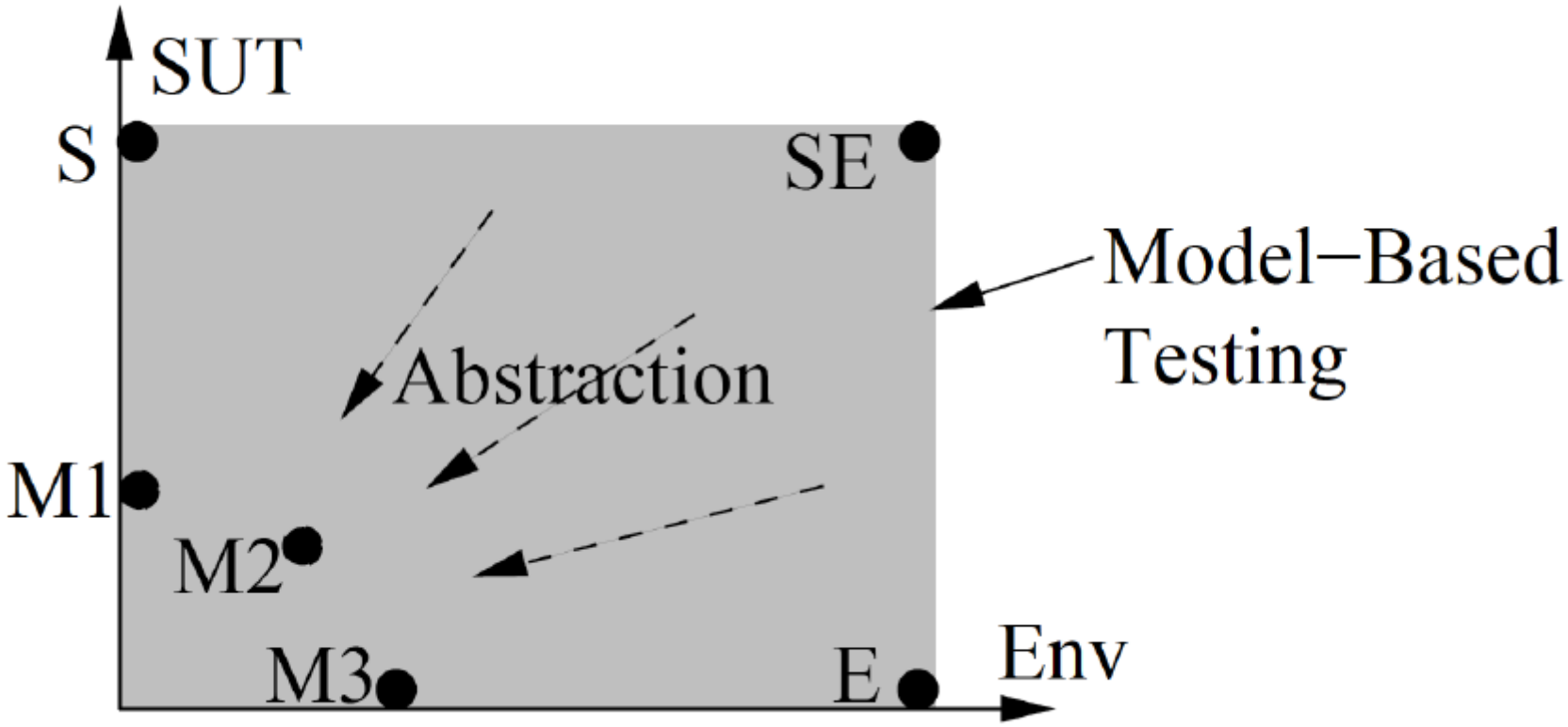
MBT model - Example

Fonctions de contrôle

CTRL001	Vérification de la lisibilité des informations des cartes présentées
CTRL002	Vérification de la date de péremption par rapport à la date du jour
CTRL003	Vérification du code saisi par le client par rapport à celui enregistré sur la carte
CTRL004	Demande d'autorisation de la carte, ainsi que la provision du compte correspondant
CTRL005	Redemande le code, s'il est erroné et si le nombre d'essais est inférieur ou égal à 2

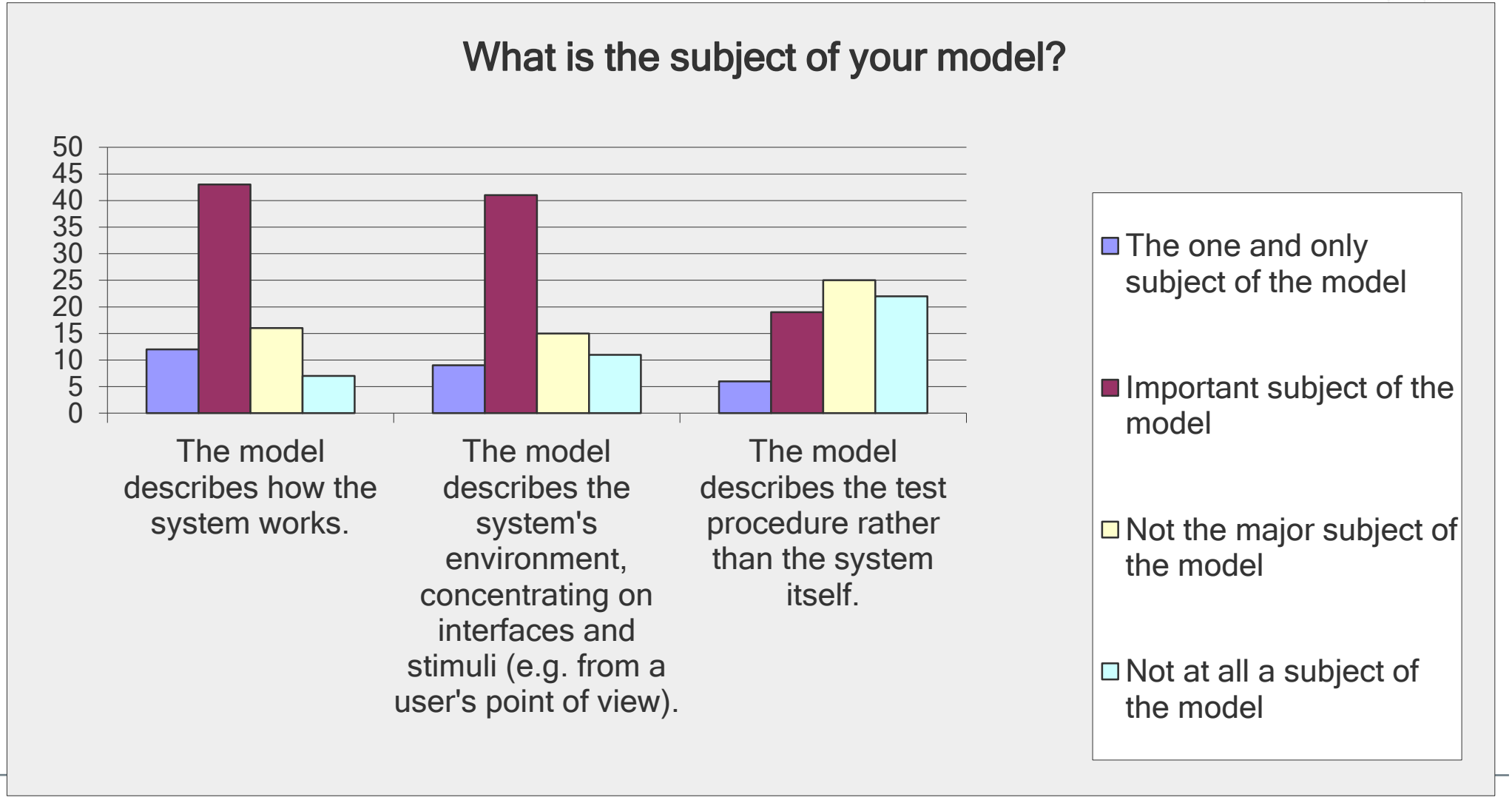
```
1  ---@REQ: CTRL003-Vérification du code saisi par le client par rapport à celui enregistré sur la carte
2  if (p_Code=CODE::FAUX)then
3      ---@REQ: INFO006-Informe le client que son code est erroné
4      afficherMessage(MESSAGE::CODE_ERRONE) and
5      nbEssaisCode = nbEssaisCode+1 and
6      if (nbEssaisCode >= 3) then
7          ---@REQ: GEST006-Confisque la carte au bout de la 3ème tentative de saisi de code avec la même carte
8          ---@REQ: INFO004-Signaler au client que sa carte est confisquée
9          ---@NAME: Trois essais code faux
10         confisquerCarte()
11     else
12         ---@REQ: CTRL005-Redemande le code, s'il est erroné et si le nombre d'essais est inférieur ou égal à 2
13         afficherMessage(MESSAGE::ENTRER_CODE)
14     endif
15 else
16     code = CODE::OK and
17     ---@REQ: INFO002-Signaler au client de saisir sa somme
18     afficherMessage(MESSAGE::ENTRER_MONTANT)
19 endif
```

Subject of the MBT model



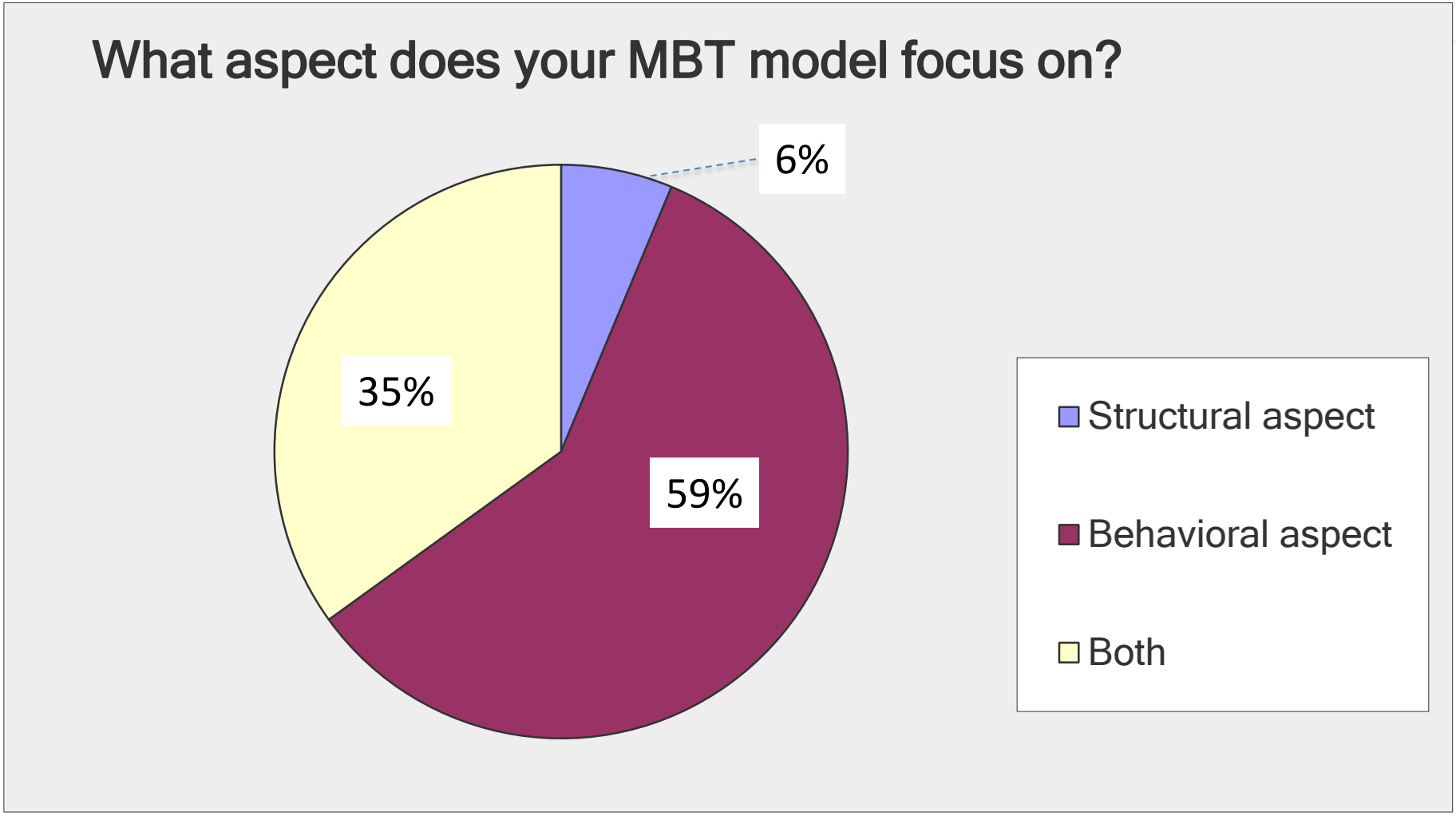
Source : Mark Utting, Alexander Pretschner, and Bruno Legeard. 2012. A taxonomy of model-based testing approaches. *Softw. Test. Verif. Reliab.* 22, 5 (August 2012), 297-312.

Subject of the MBT model



Source: MBT User Survey 2014

Focus of the MBT model

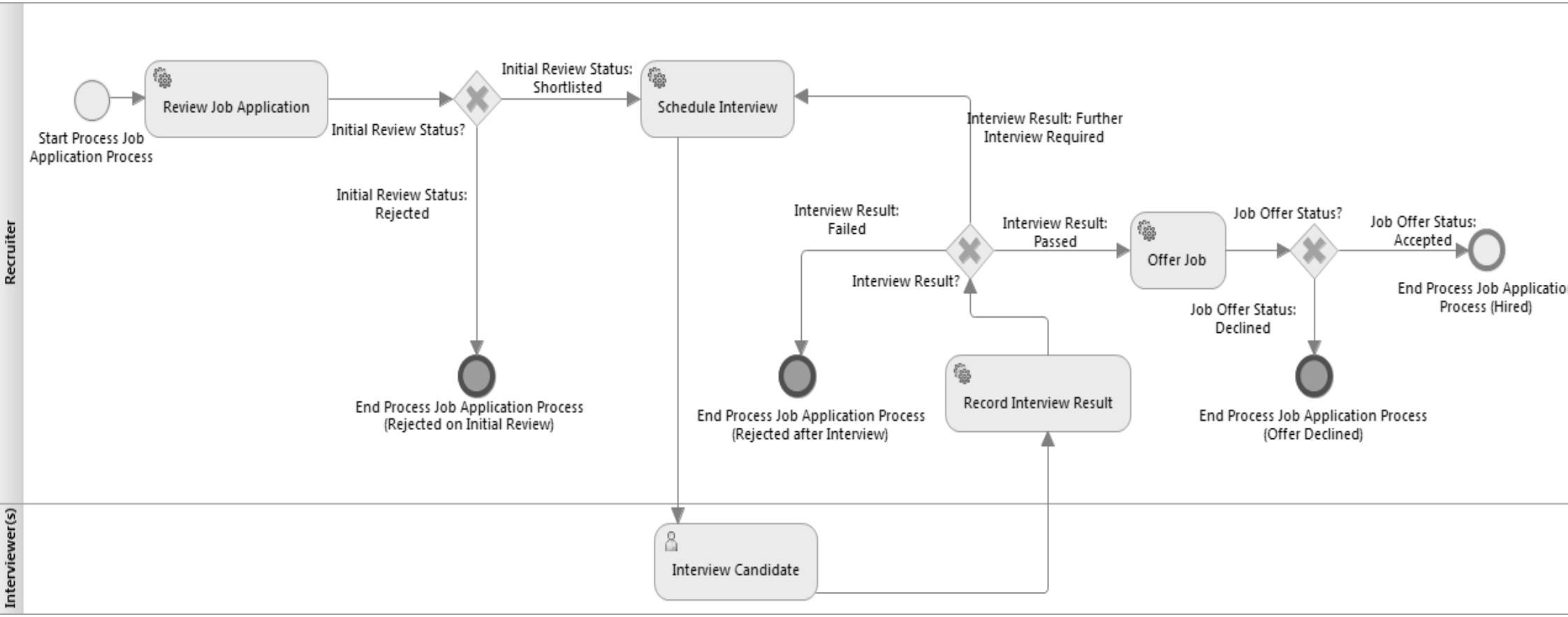


Source: MBT User Survey 2014

Modeling paradigms for MBT

- Many modeling paradigms used for MBT:
  - Behavioral modeling (not exhaustive)
    - Flow Charts / BPMN / UML activity diagram
    - Data Flow Diagrams
    - Finite state machine – Statecharts – UML state machines
    - Pre-post conditions / OCL
    - Markov chain
    - Event Sequence Graph
    - Domain specific languages
  - Structural modeling (Point of control & observation)
    - UML calss diagram
    - Block diagram
- Representation :
  - Graphical (more « intuitive »)
  - Textual / formal (more precise)

MBT modeling - BPMN



MBT modeling – OCL-based

*Main *DiagrammeObjet1 mount

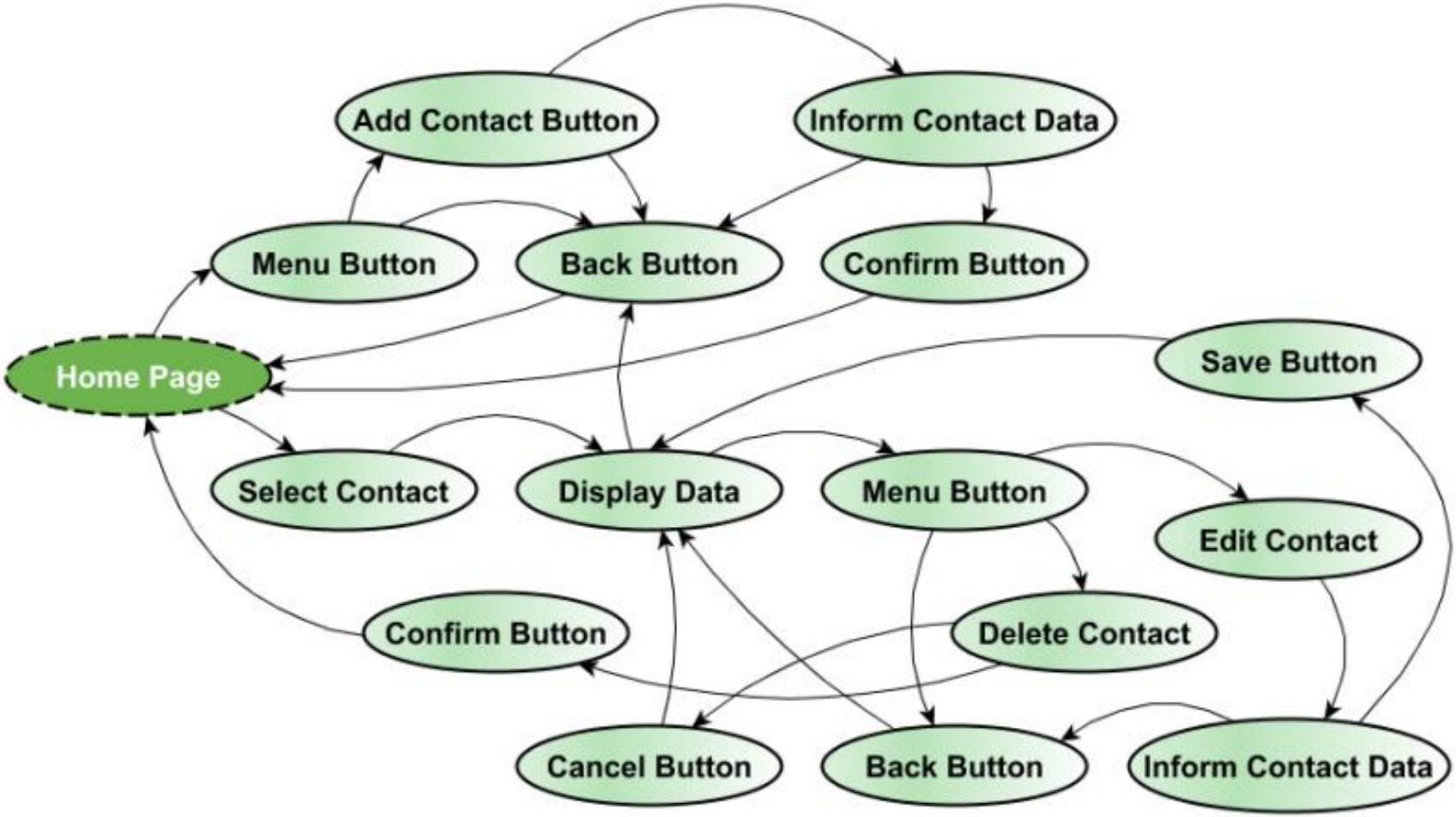
```
self.resetExceptions() and
let invalidFileName : Boolean = (mountPointName = MOUNT_POINT_NAMES::INVALID_NAME) in
let mountPointAlreadyExists : Boolean = (self.mountPoints->exists(mp|mp.name=mountPointName)) in
let invalidFileSystem : Boolean = fileSystem.isNull in

---@REQ: 3.1.3.4.3.5.1
if (not(invalidFileName) and not(mountPointAlreadyExists) and not(invalidFileSystem)) = true
then
    ---@AIM: MOUNT_OK
    let newMountPoint:MountPoint = MountPoint.allInstances()->any(mp|mp.name=MOUNT_POINT_NAMES::UNDEFINED_NAME) in

    newMountPoint.name = mountPointName and
    newMountPoint.fileSystem = fileSystem and
    self.mountPoints->includes(newMountPoint)
else
    ---@AIM: MOUNT_KO
    if (invalidFileName)
    then
        ---@AIM: INVALID_FILE_NAME
        self.raiseInvalidFileNameException()
    else
        if (mountPointAlreadyExists)
        then
            ---@AIM: MOUNT_POINT_ALREADY_EXISTS
            self.raiseMountPointAlreadyExistsException()
        else
            true
        endif
    endif

    and if (invalidFileSystem)
    then
        ---@AIM: INVALID_FILE_SYSTEM
        self.raiseInvalidFileSystemException()
    else
        true
    endif
endif
```

Event Sequence Graph



Reuse of existing design models

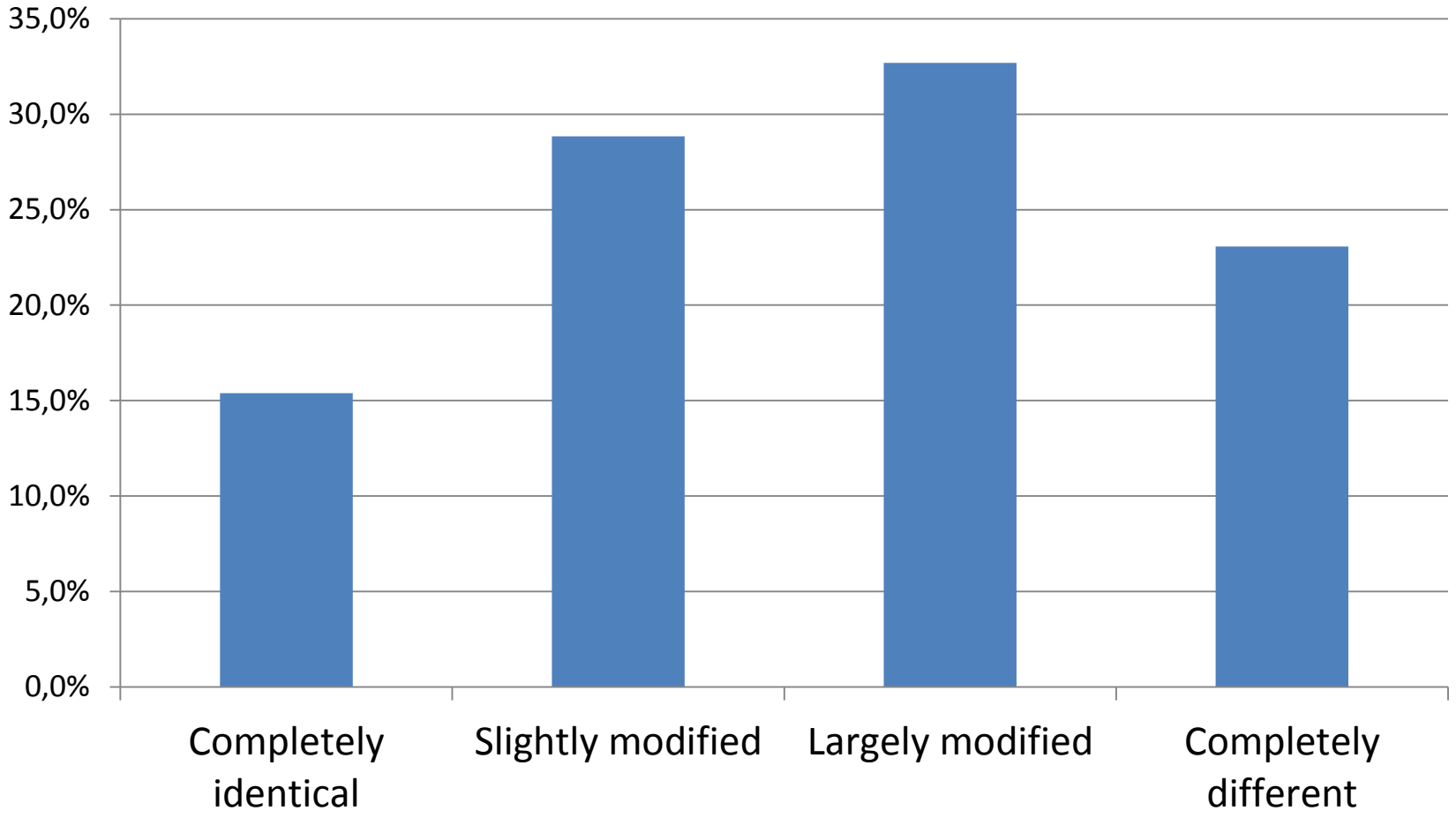
Can we re-use design models for MBT?

In principle Yes, but:

- The reused model is it at the right abstraction level to adress my test objectives?
- Is it complete enougch to adress my test objectives?
- Does my MBT tool manage such model?

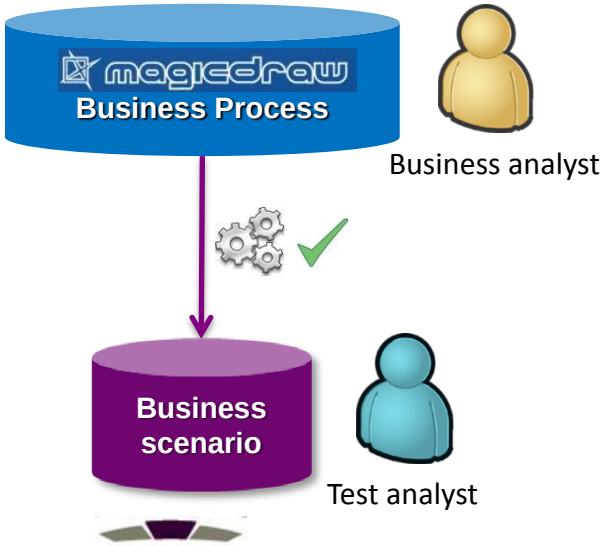
Reuse of existing design model

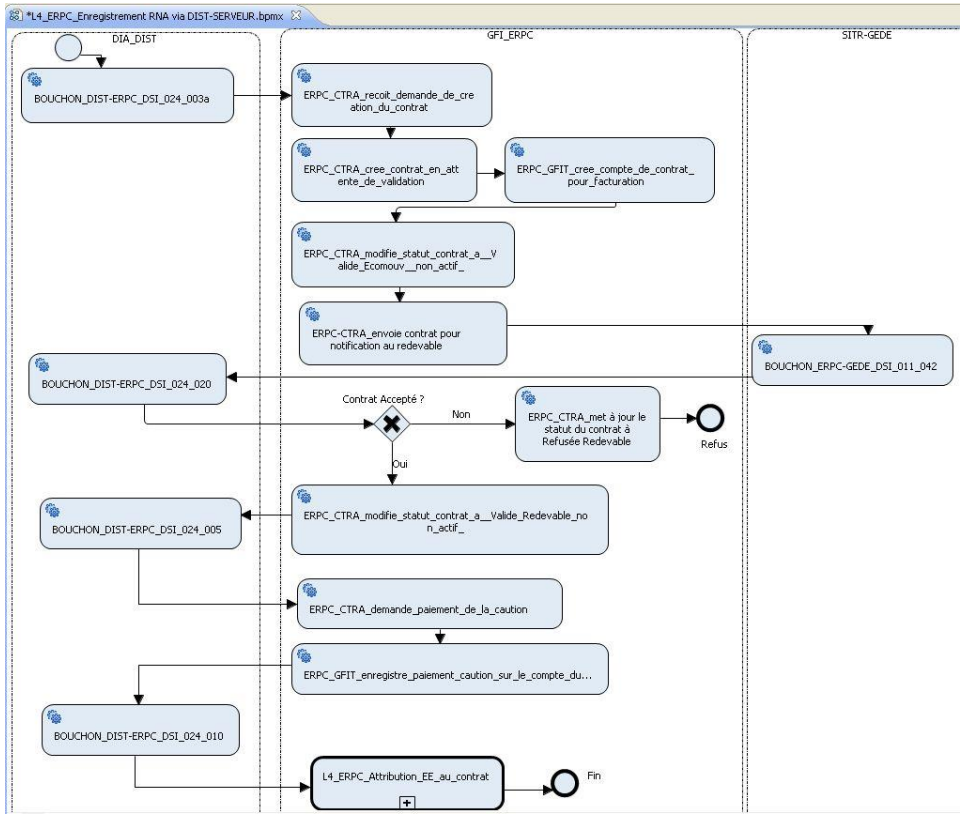
If you use models both for analysis or design and for testing activities, how different are these models?



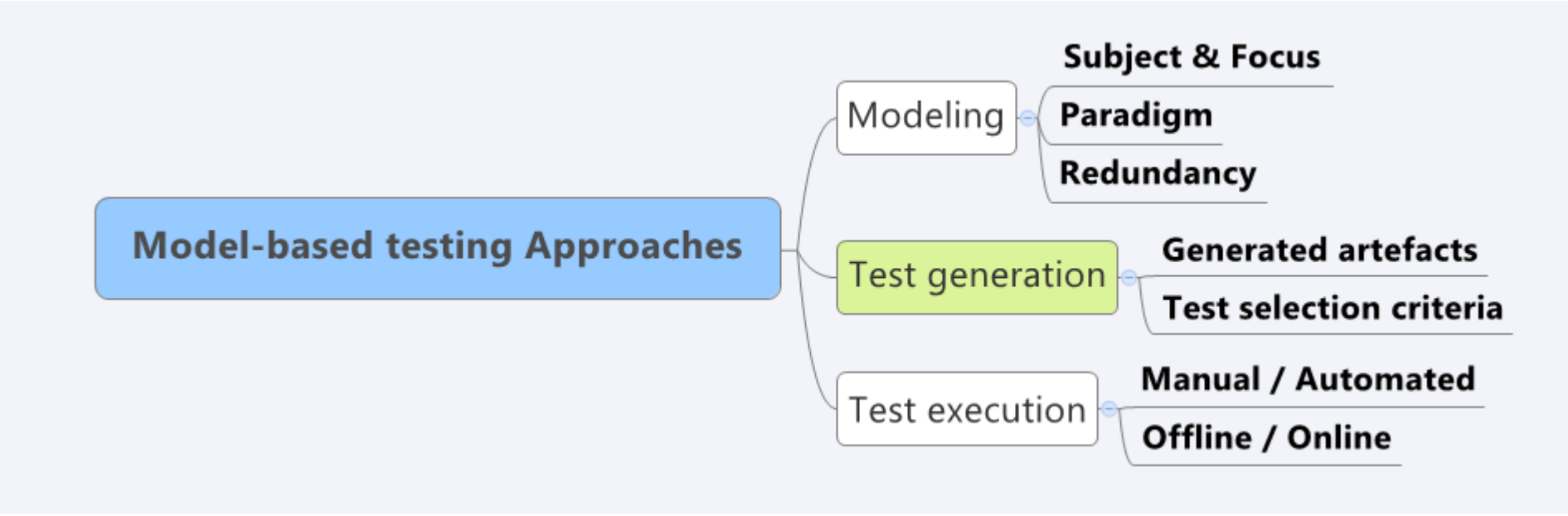
Source: MBT User Survey 2014

Reuse of models - Example

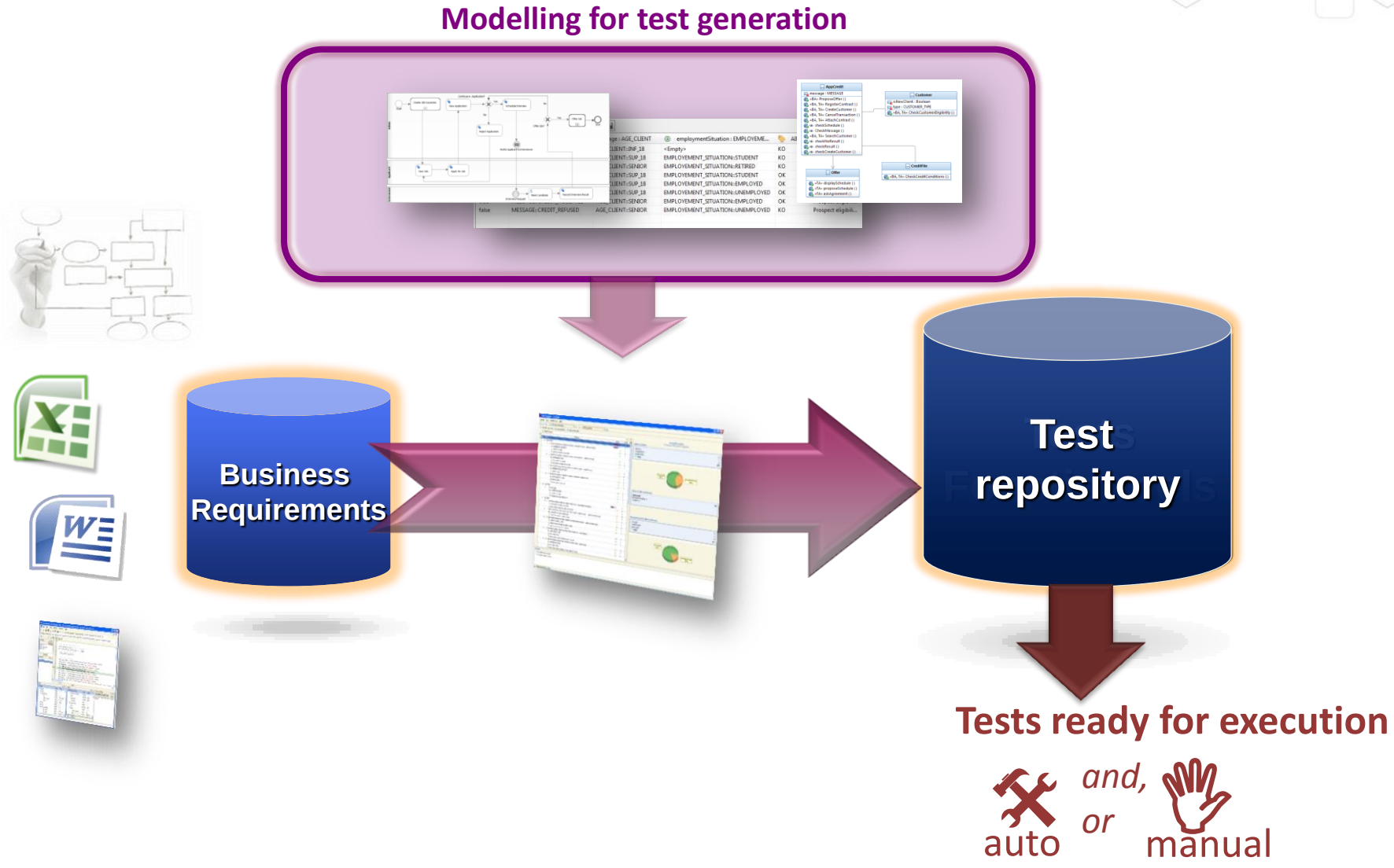




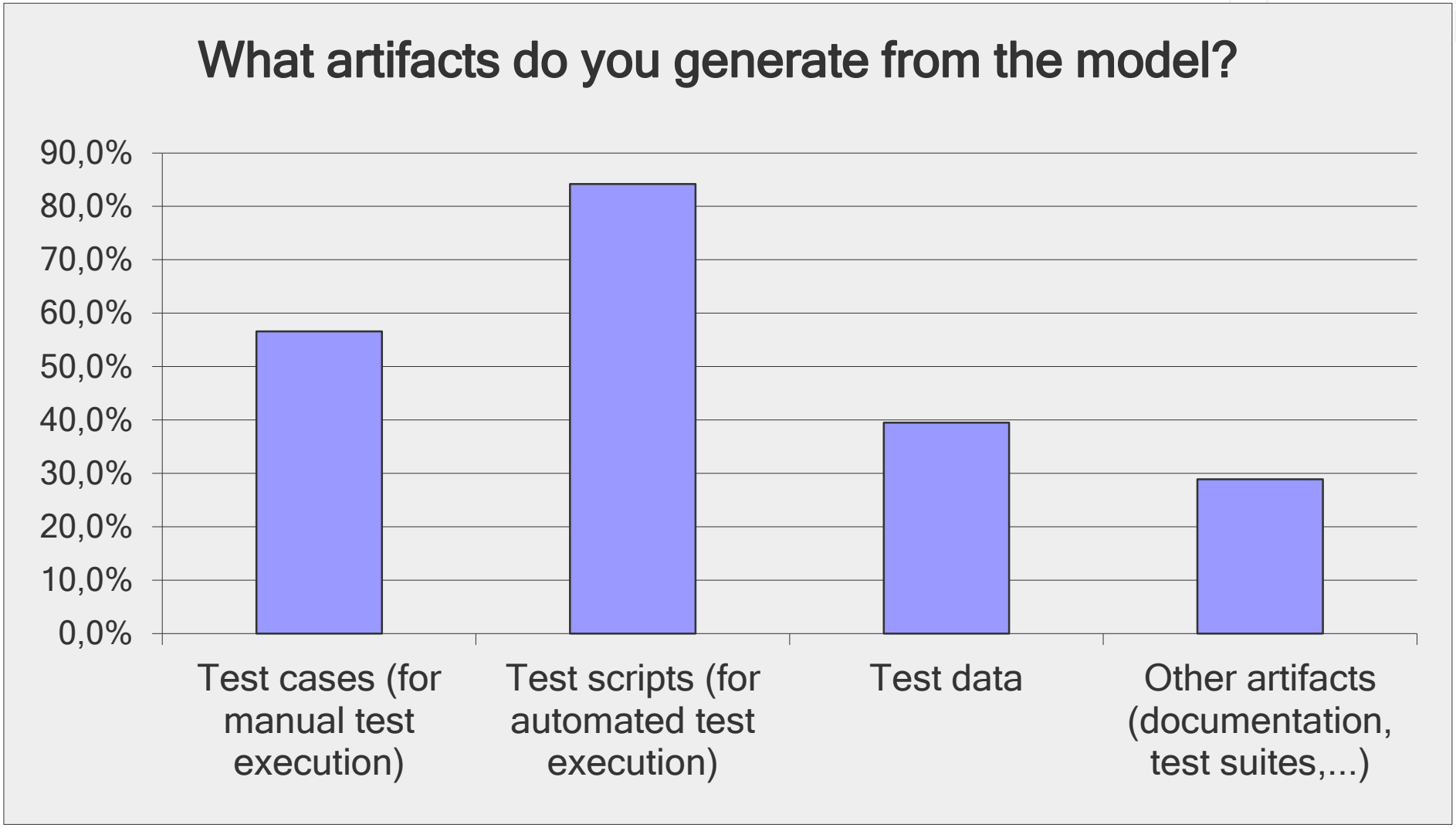
Taxonomy of MBT approaches



Generation of the test repository

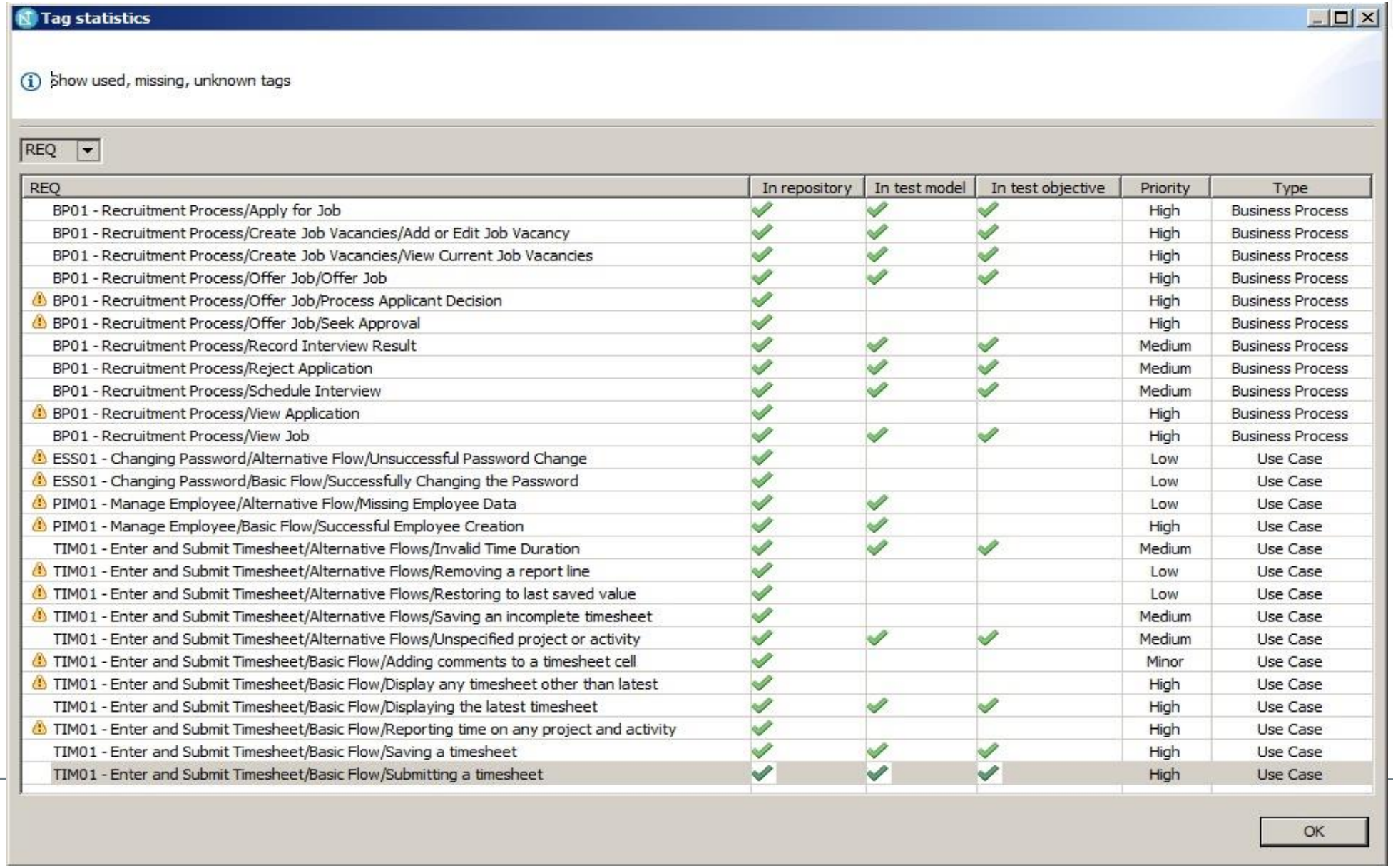


MBT generated artifacts



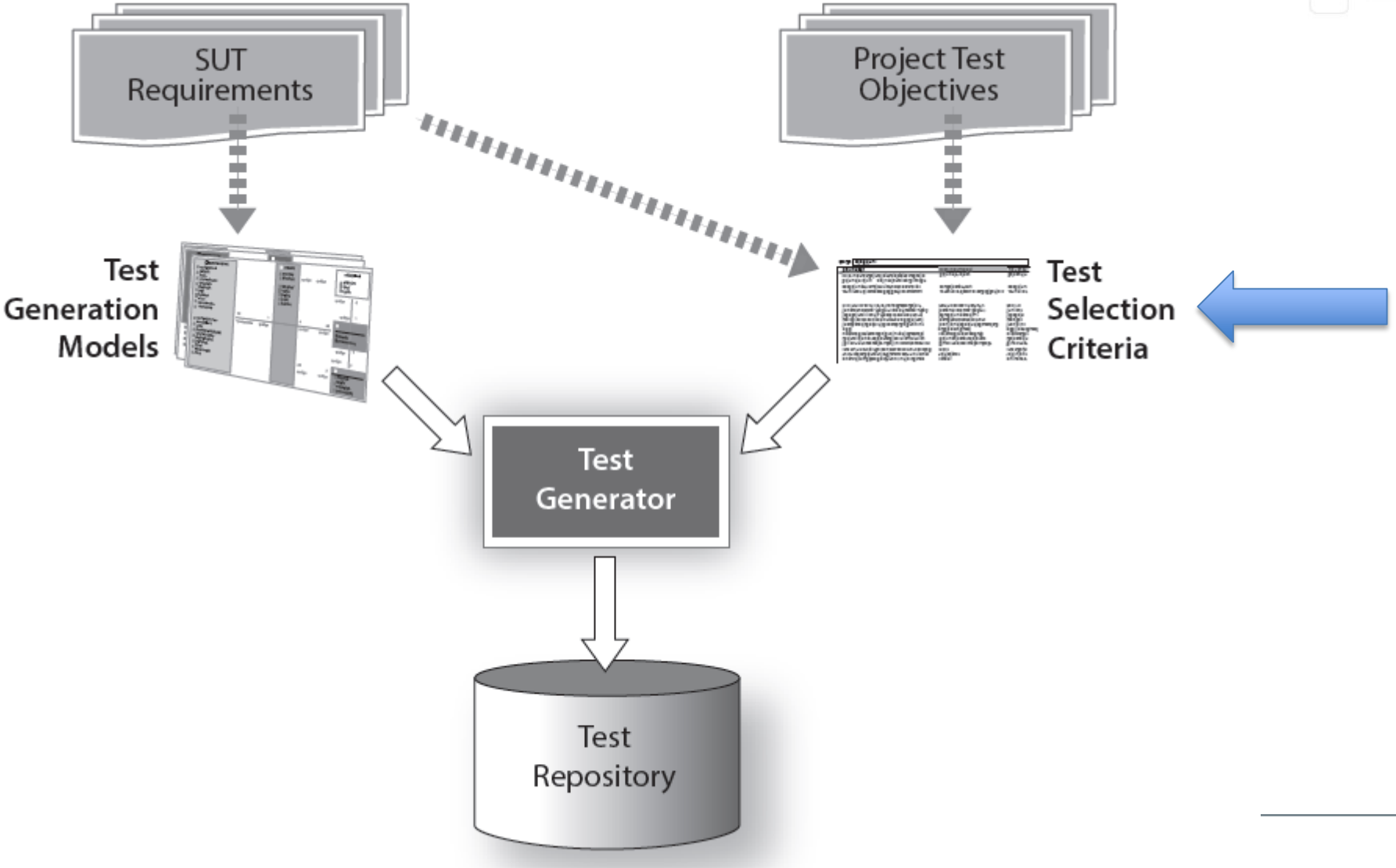
Source: MBT User Survey 2014

Traceability matrix

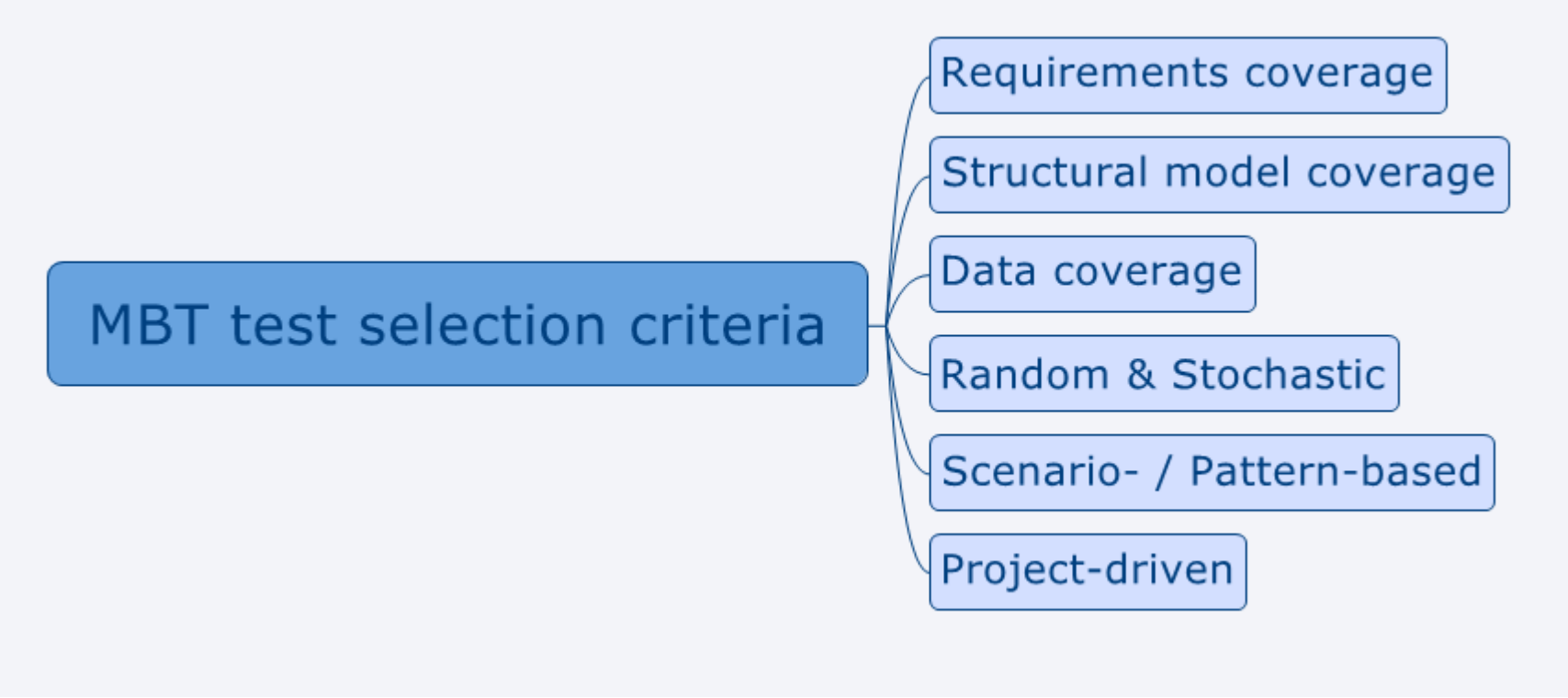


REQ	In repository	In test model	In test objective	Priority	Type
BP01 - Recruitment Process/Apply for Job	✓	✓	✓	High	Business Process
BP01 - Recruitment Process/Create Job Vacancies/Add or Edit Job Vacancy	✓	✓	✓	High	Business Process
BP01 - Recruitment Process/Create Job Vacancies/View Current Job Vacancies	✓	✓	✓	High	Business Process
BP01 - Recruitment Process/Offer Job/Offer Job	✓	✓	✓	High	Business Process
BP01 - Recruitment Process/Offer Job/Process Applicant Decision	✓			High	Business Process
BP01 - Recruitment Process/Offer Job/Seek Approval	✓			High	Business Process
BP01 - Recruitment Process/Record Interview Result	✓	✓	✓	Medium	Business Process
BP01 - Recruitment Process/Reject Application	✓	✓	✓	Medium	Business Process
BP01 - Recruitment Process/Schedule Interview	✓	✓	✓	Medium	Business Process
BP01 - Recruitment Process/View Application	✓			High	Business Process
BP01 - Recruitment Process/View Job	✓	✓	✓	High	Business Process
ESS01 - Changing Password/Alternative Flow/Unsuccessful Password Change	✓			Low	Use Case
ESS01 - Changing Password/Basic Flow/Successfully Changing the Password	✓			Low	Use Case
PIM01 - Manage Employee/Alternative Flow/Missing Employee Data	✓	✓		Low	Use Case
PIM01 - Manage Employee/Basic Flow/Successful Employee Creation	✓	✓		High	Use Case
TIM01 - Enter and Submit Timesheet/Alternative Flows/Invalid Time Duration	✓	✓	✓	Medium	Use Case
TIM01 - Enter and Submit Timesheet/Alternative Flows/Removing a report line	✓			Low	Use Case
TIM01 - Enter and Submit Timesheet/Alternative Flows/Restoring to last saved value	✓			Low	Use Case
TIM01 - Enter and Submit Timesheet/Alternative Flows/Saving an incomplete timesheet	✓			Medium	Use Case
TIM01 - Enter and Submit Timesheet/Alternative Flows/Unspecified project or activity	✓	✓	✓	Medium	Use Case
TIM01 - Enter and Submit Timesheet/Basic Flow/Adding comments to a timesheet cell	✓			Minor	Use Case
TIM01 - Enter and Submit Timesheet/Basic Flow/Display any timesheet other than latest	✓			High	Use Case
TIM01 - Enter and Submit Timesheet/Basic Flow/Displaying the latest timesheet	✓	✓	✓	High	Use Case
TIM01 - Enter and Submit Timesheet/Basic Flow/Reporting time on any project and activity	✓			High	Use Case
TIM01 - Enter and Submit Timesheet/Basic Flow/Saving a timesheet	✓	✓	✓	High	Use Case
TIM01 - Enter and Submit Timesheet/Basic Flow/Submitting a timesheet	✓	✓	✓	High	Use Case

Test selection criteria

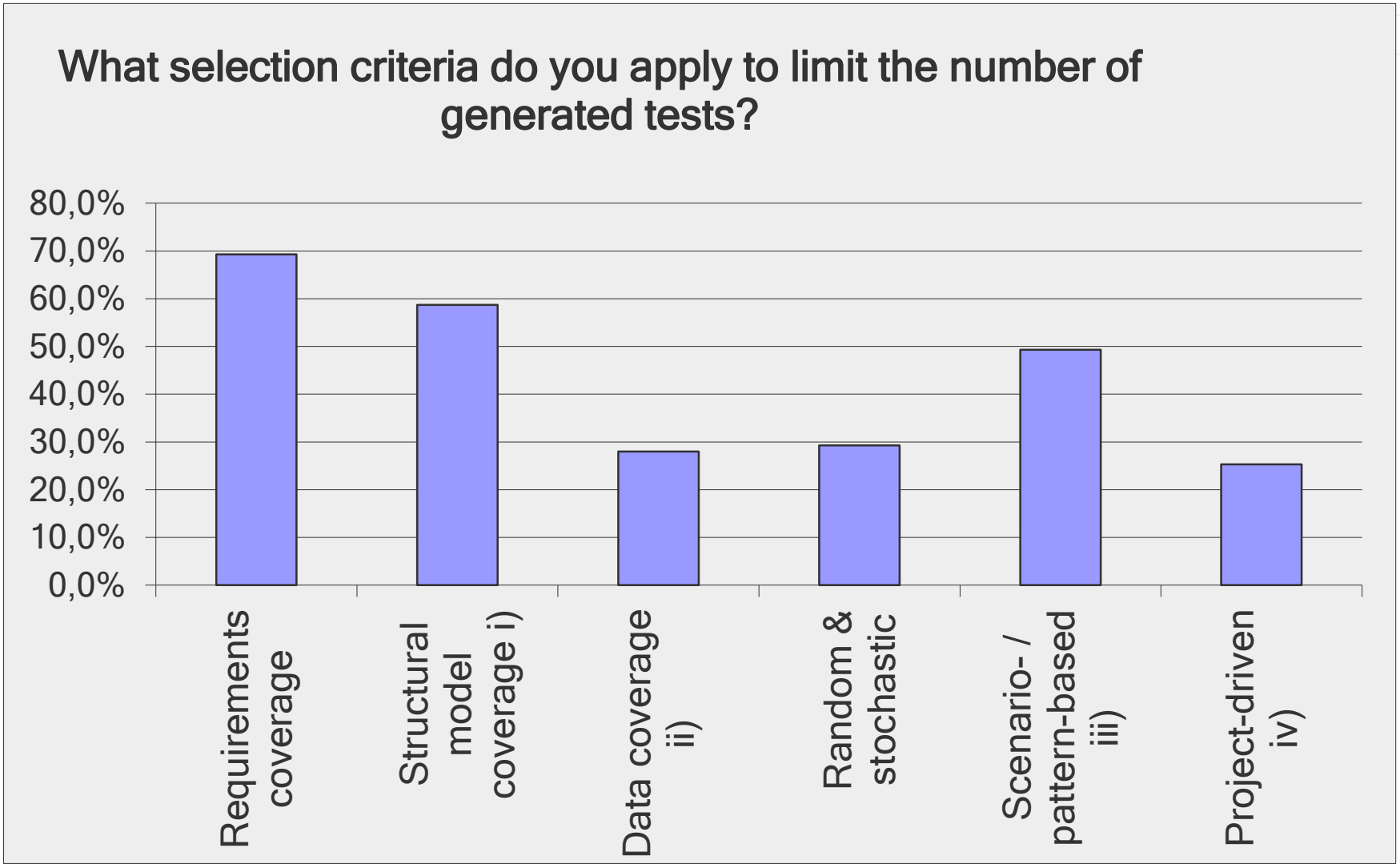


Test selection criteria



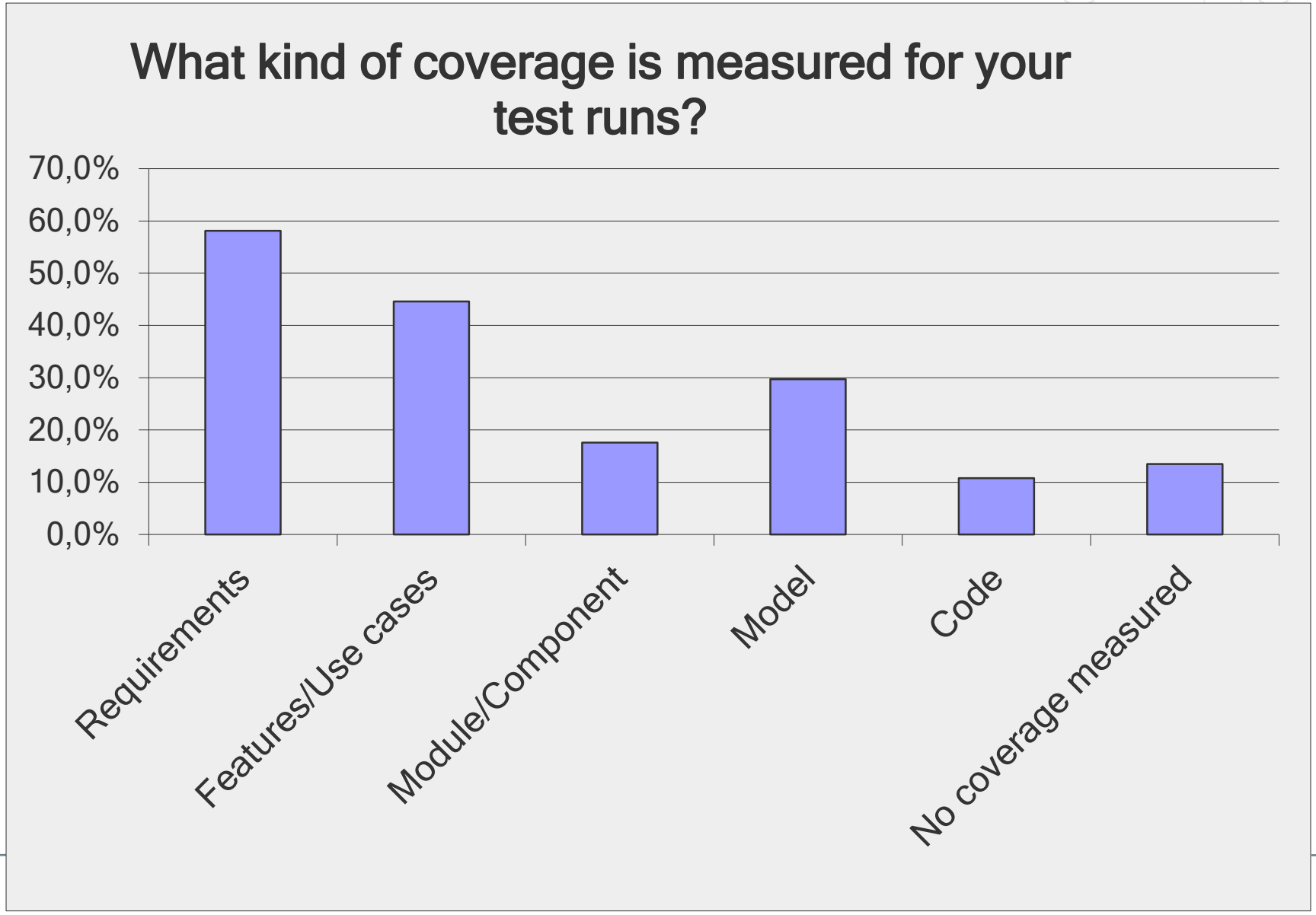
Source : ISTQB – Certification Model-Based Testing

Test selection criteria



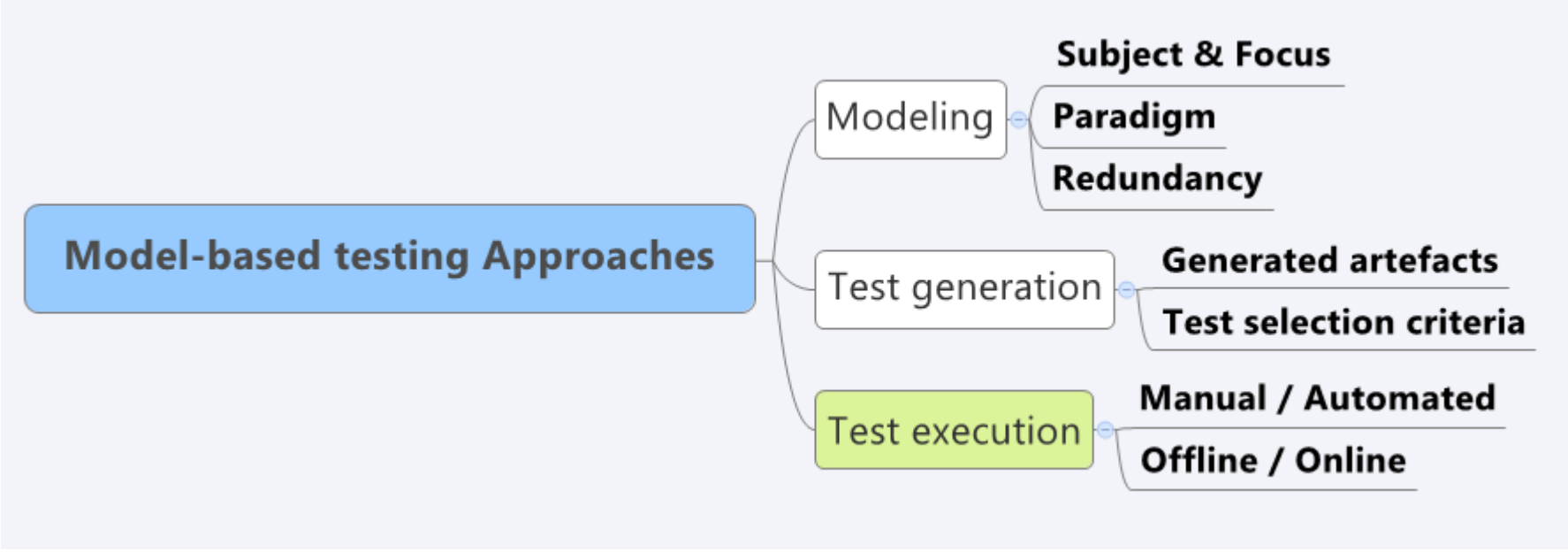
Source: MBT User Survey 2014

Coverage monitoring



Source: MBT User Survey 2014

Taxonomy of MBT approaches



MBT test execution

- Manual test execution
- Offline MBT
- Online MBT

Offline MBT	*"Model-based testing approach whereby test cases are generated into a repository for future execution."*
Online MBT	*"Model-based testing approach whereby test cases are generated and executed simultaneously."*

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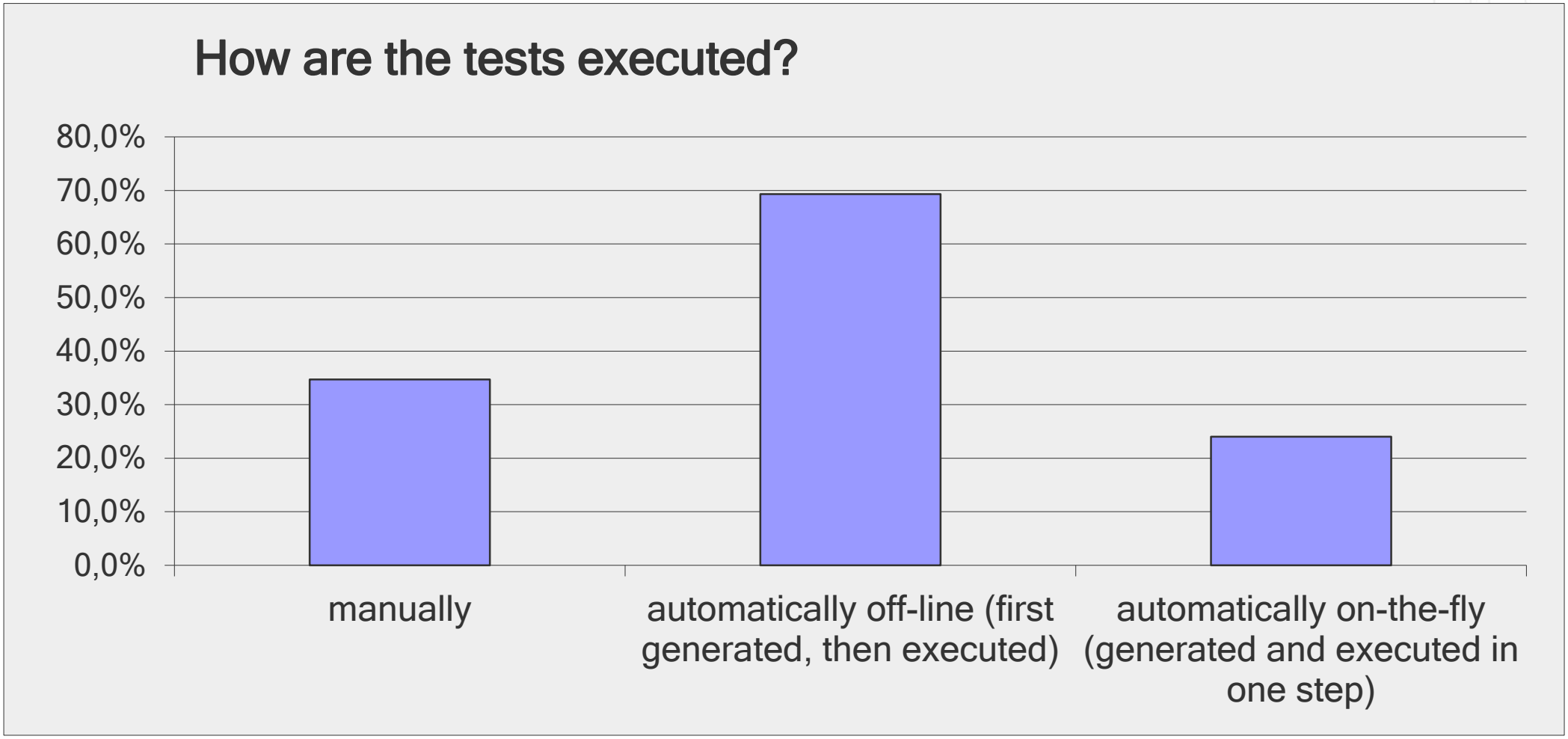
MBT test execution



Source: MBT User Survey 2014

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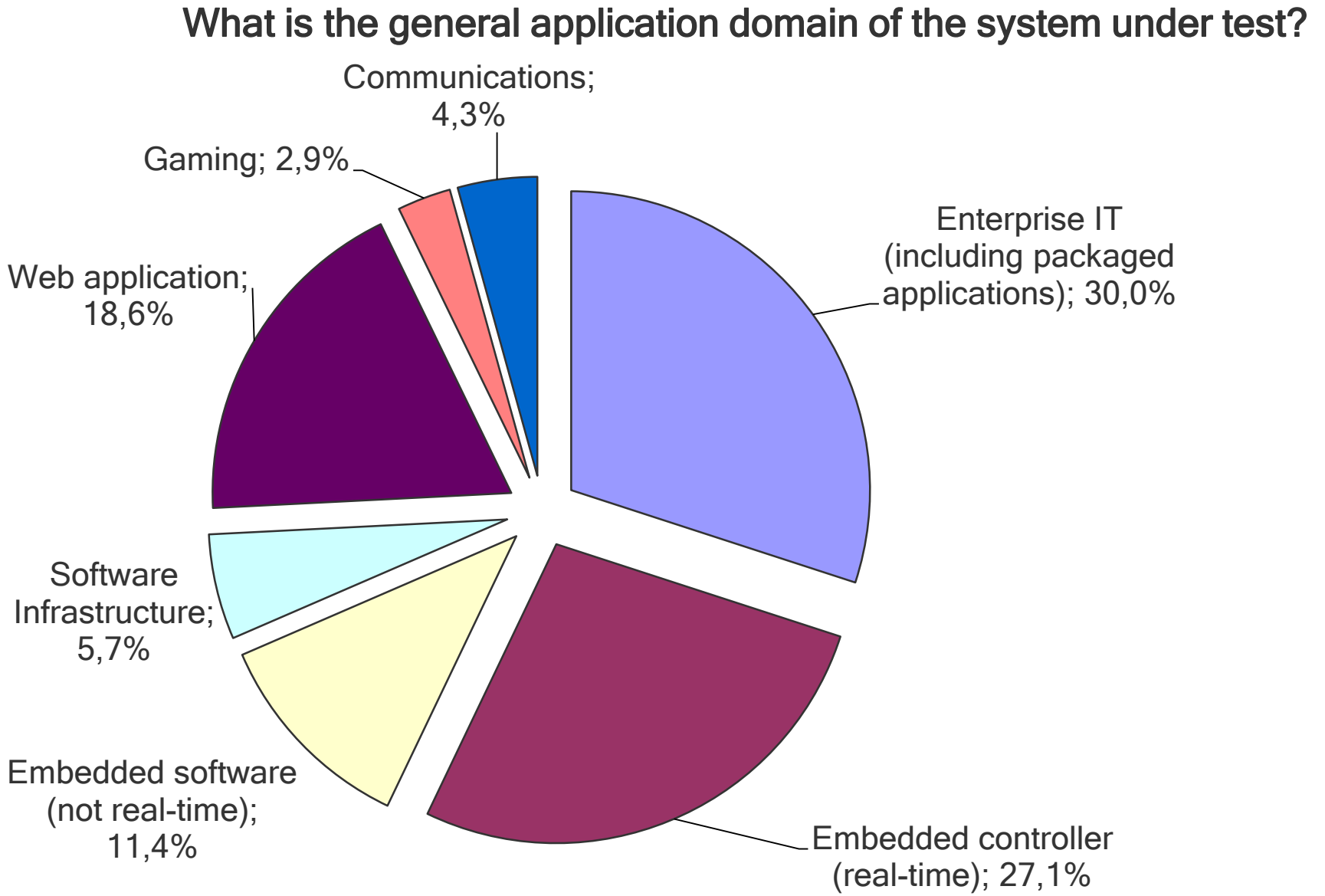
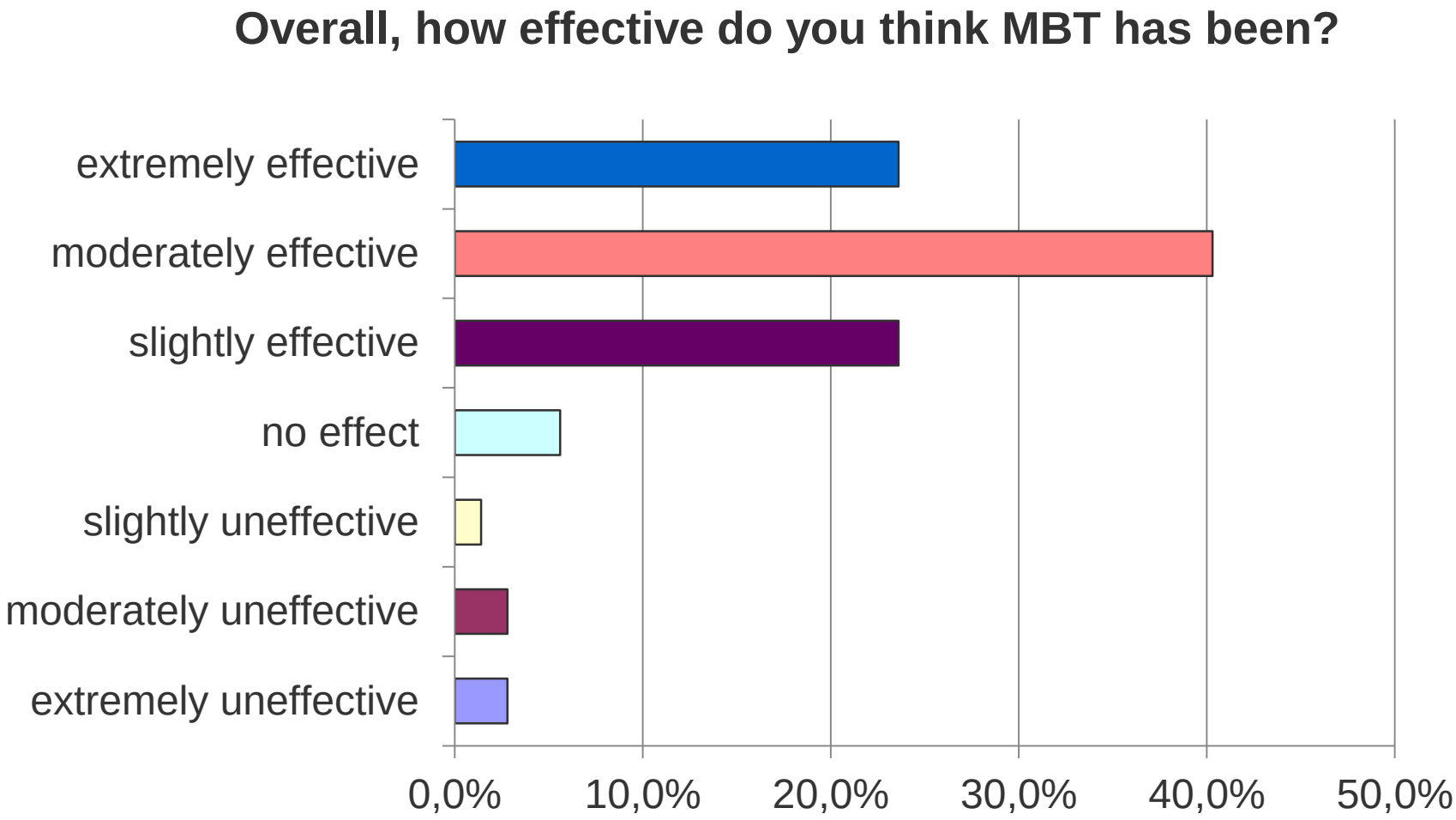
3. **Application domains**
4. Conclusion

Application domains



Satisfaction level of MBT users



Source: MBT User Survey 2014

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An emerging technology in industry

Testing Methods Used in the Automotive Industry: Results from a Survey

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Re – Research
PD – Pre Development
SD – Serie Development
TE - TEsting related department

Table 8: test methodes in use

	Re	PD	SD	TE
	[%]	[%]	[%]	[%]
fuzzy testing	0,00	3,37	3,37	2,96
model based testing	32,26	32,58	35,96	38,52
mutation testing	3,23	3,37	3,37	2,96
random testing	9,68	8,99	6,74	7,41
test driven dev.	25,81	20,22	15,73	19,26
unit testing	29,03	31,46	34,83	28,89

Source : Harald Altinger, Franz Wotawa, and Markus Schurius. 2014. Testing methods used in the automotive industry: results from a survey. In *Proceedings of the 2014 Workshop on Joining AcadeMiA and Industry Contributions to Test Automation and Model-Based Testing* (JAMAICA 2014). ACM, New York, NY, USA, 1-6.

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Thanks for your attention

Source - http://model-based-testing.info

Questions on Part I?