

TIE Lessons Learned (from an Academic Perspective)

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*More details are available off the ARPI TIEs' Web page,
or directly in <http://www.cs.cmu.edu/~mmv/arpi-mi.html>.*

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Rationale Capture and Reuse in Mixed-Initiative Planning

Alice Mulvehill, Mitre
Steve Christey, Mitre

Manuela Veloso, CMU
Michael Cox, CMU

Integrate the capabilities of Prodigy/Analogy and ForMAT for the continued acquisition and generation of planning cases.

The goal is to support the user with an interactive environment where past cases can be recalled and adapted interactively by the user or automatically using the rationale underlying the original plan.

As a starting point we will experiment with the existing force module case-base of ForMAT and we plan to extend our efforts to include the Air Campaign Planning domain.

The Scenario

- Two **developed** and **large** systems: ForMAT and Prodigy.
- Two different environments:
 - CMU - academic, **little knowledge of users**
 - Mitre - government lab, **large knowledge of users**
- Two different perspectives:
 - **ForMAT**
 - * user-driven case-based planner
 - * real cases stored (deployment TPFDDs)
 - * sophisticated browsing and retrieval
 - * case functional analysis
 - * no automated adaptation
 - **Prodigy and Prodigy/Analogy**
 - * fully-automated planner
 - * well-structured domain knowledge
 - * manufactured domains (even if realistic)
 - * disciplined knowledge organization
 - * interpretable planning cases
 - * full-automated storage, retrieval, and adaptation

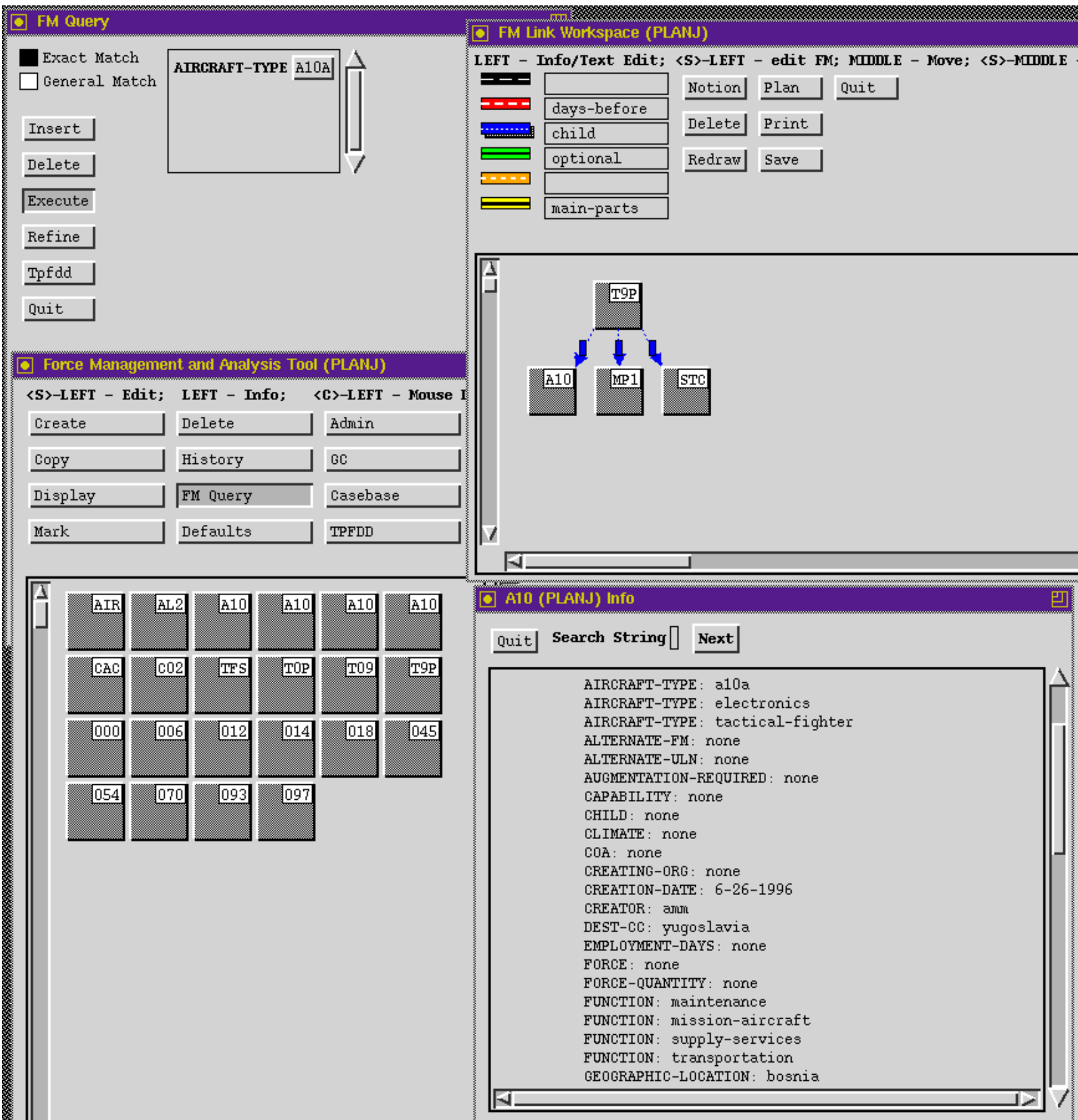
Making it Possible to Proceed

- Layered system understanding: decomposition of system at different levels of detail.
- Effort to break the terminology gap between users and research communities.

“Stubbornness” to make it work!

- Aim to identify issues already solved by the technology developed in research systems.
- Determination to find new research issues.

Snapshot of ForMAT's Interface



Snapshot of ForMAT's Goal Editor

Goal Editor (PLANJ - planj-guidance)

Copy To FM Fields Execute Query

Check Plan Operations Quit

Search String Next

DEPLOY-TFS
SECURE-AIRPORT
SEND-MILITARY-POLICE
SECURE-TOWN-CENTER-HALL

AIRCRAFT	AC-QUANT	GEOGRAPH	FORCE-QU	FORCE
A10A	3	BOSNIA	NONE	NONE
NONE	NONE	BOSNIA	NONE	NONE
NONE	NONE	BOSNIA	1	MILITARY
NONE	NONE	BOSNIA	NONE	NONE

Add Sort

Example Message from Prodigy to ForMAT

Wed Jul 24 07:35:11 1996

Emacs@yoyoma-prodigy.cs.cmu.edu

Buffers File Edit Complete In/Out Signals Help

9 n9 (airport-secure-at bosnia) [g:2]
 11 n11 <secure airport4 bosnia> [55]
 12 n12 (is-deployed hawk4 bosnia) [g:3]
 14 n14 <send hawk4 bosnia>
 15 n1
 16 n1
 18 n1 (:ON-ACTION ("7/17/1996: 16:00:30" :SAVE-GOALS
 19 n1 "/NFS/ai/systems/cbr/format1.4.1/data/prodigy/planj-guidance"
 20 n20 (1 PLANJ
 21 n21 (:DESCRIPTION
 22 n22 "goal: Provide military police to secure the town and the airstri
 23 n23 p in
 24 n24 Tuzla so that military a/c can land there. Deploy 3 squadrons of
 25 n25 A-10s to Aviano to provide CAS to the Bosnia AOR (Area of
 26 n26 Responsibility).
 27 n27 ")
 28 n28 (:GOALS
 29 n29 (38 :SECURE-TOWN-CENTER-HALL PLANJ NIL NIL NIL
 30 n30 ((GEOGRAPHIC-LOCATION BOSNIA)))
 31 n31 (37 :SEND-MILITARY-POLICE PLANJ NIL NIL (35)
 32 n32 ((FORCE MILITARY-POLICE) (GEOGRAPHIC-LOCATION BOSNIA)
 33 n33 ((FORCE-QUANTITY 11)))
 34 n34 (36 :DEPLOY-TFS PLANJ NIL NIL NIL
 35 n35 ((GEOGRAPHIC-LOCATION BOSNIA)))
 36 n36 (35 :SECURE-AIRPORT PLANJ NIL (37) NIL
 37 n37 ((GEOGRAPHIC-LOCATION BOSNIA)))
 38 n38 (:GUIDANCE-FILE "planj-guidance"))
 39 n39 (:MESSAGE 18 "The goals of PLANE are most similar to this plan.")
 40 n40)
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 100 n100)

Solution:
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Writing ou
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***Emacs: *inferior-lisp* 7:35am (Inferior Lisp:run)--Bot-----
 Garbage collecting...done

Watch Dog

cd
 cd /tmp/PRODIGY

server /tmp/PRODIGY.server.2
 client /tmp/PRODIGY.client.2
 client /tmp/PRODIGY.client.2
 client /tmp/PRODIGY.client.3
 client /tmp/PRODIGY.client.3
 client /tmp/PRODIGY.client.4
 client /tmp/PRODIGY.server.1

server /tmp/PRODIGY.server.2
 client /tmp/PRODIGY.client.4
 client /tmp/PRODIGY.client.5
 client /tmp/PRODIGY.server.2

Icons

xelock
 yoyoma,prodi:
 UX1
 enacs@ux1.sp
 xbiff
 enacs@yoyoma
 WatchDog
 Advice 2
 xbiff
 Advice 1

Suggested Plan Modifications

● Prodigy Tasks

Execute

Quit

Sort

Select I to ignore the task.
Select A to accept the task.
Select R to reject the task.

◆ I	◆ A	◆ R	Change POD, POD-CC, DEST, and DEST-CC to places in or near BOSNIA in FM (FM DEL PLANJ)
◆ I	◆ A	◆ R	Add or create a Force Module to address goal (:SECURE-TOWN-CENTER-HALL (AIRCRAFT-TYPE NONE) (FORCE NONE) (GEOGRAPHIC-LOCATION BOSNIA) (AC-QUANTITY NONE) (FORCE-QUANTITY NONE)).
◆ I	◆ A	◆ R	Remove BRIGADE Force Module from Plan.
◆ I	◆ A	◆ R	Remove HAWK-BATTALION Force Module from Plan.
◆ I	◆ A	◆ R	Change SECURITY-POLICE to MILITARY-POLICE.
◆ I	◆ A	◆ R	Change F-15 to A10A.
◆ I	◆ A	◆ R	The goals of PLANC are most similar to this plan.
◆ I	◆ A	◆ R	The following cases are also relevant: (PLANE).

Main Research Issues Addressed

- **Interpretation** of users' objectives and scenario into rationale and action model.
- Under-specified goal statement from users: planner plans for **existentially quantified** goal statements.
- Users specify goals that are subgoals of other goals: planner focuses on **higher-level goals** and refinement brings up the subgoals.
- Users expect plans of good quality: selection of resources to **opportunistically** achieve multiple objectives.
- Definition of communication **triggers** to enable interaction.
- **Class organization** of planning actions (e.g. all the "send" operators) – some fully subsume others.
- **Learning** from users' history and reaction to guidance suggested.

What DID NOT and DID Work

- **DID NOT: Automated translation** of TPFDDs into classic planning operators.
 - Seemed feasible, because there is a large set of rules (250) that explains the meaning of each field.
 - Became infeasible, when several inconsistent and incomplete situations were found between users' practice and the rules.
 - **DID: Definition of simpler planning model that allows the automated planner to plan at the force module level.**
- **DID NOT: Automated understanding** of ForMAT log files.
 - Seemed feasible, because a log file is system generated and therefore contains closed-world statements.
 - Became infeasible, due to the complexity of the possible combinations of users' actions, of the users' browsing, and of the users' "mistakes" or "mind changes."
 - **DID: Definition of communication triggers to focus systems' attention to each other.**

The Rewarding and Real Facts

It works!

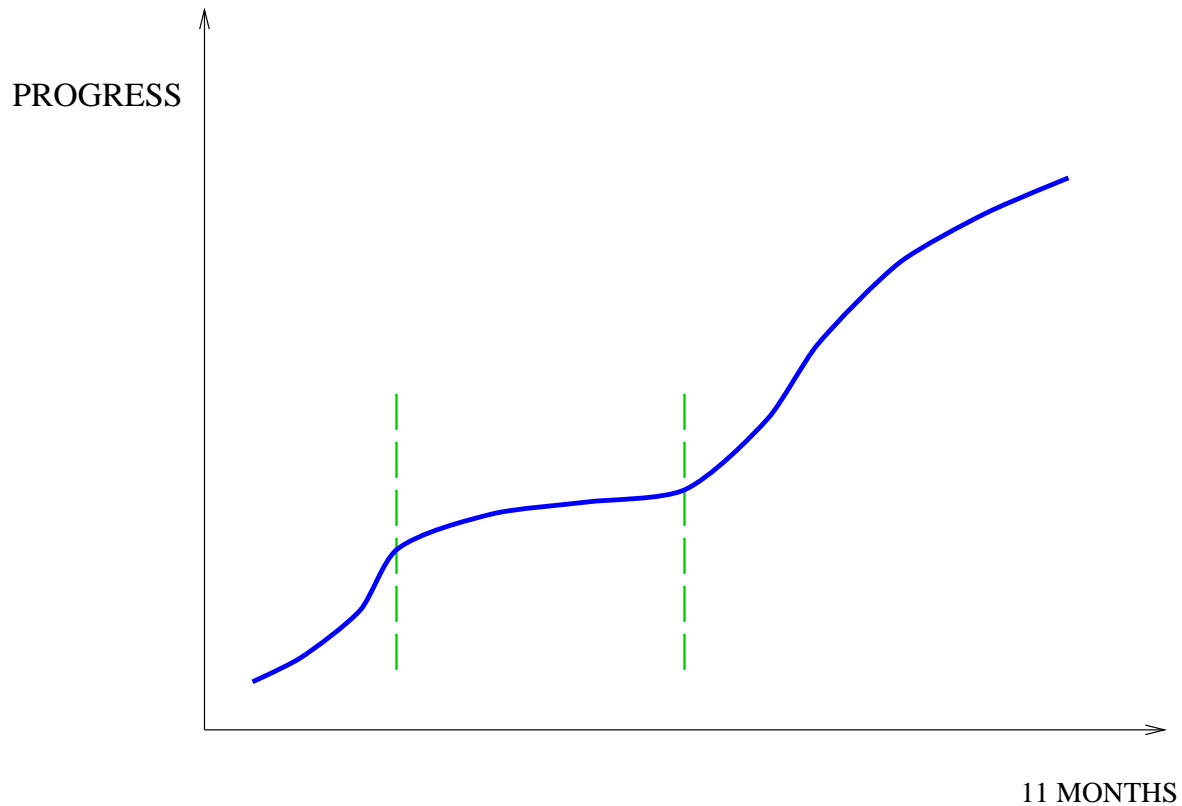
- Communication links: No need to fully delve into the systems.
- Much better appreciation of systems' contributions.
- Use of case-based planning technology was appropriate to bridge the gap between human and machine planners.
- Several challenging research issues were identified.
- Better understanding of users' planning practice.

**Users have long history
of planning practice.**

Summary - Some Contributions of TIE

- ForMAT can run with Prodigy/Analogy providing guidance to user.
- Integration of automated planning with a user planning interface.
- Handle of weak rationale available: [suggestions](#) of modifications.
- User can ignore, accept, or reject guidance.
- Learning opportunity through history of user's reaction to guidance.

The Progress Curve



- Positive second derivative: enthusiasm, trust, some lack of realism
- Plateau: the overwhelming reality
- Steepest slope: simplification, persistence, dedicated effort