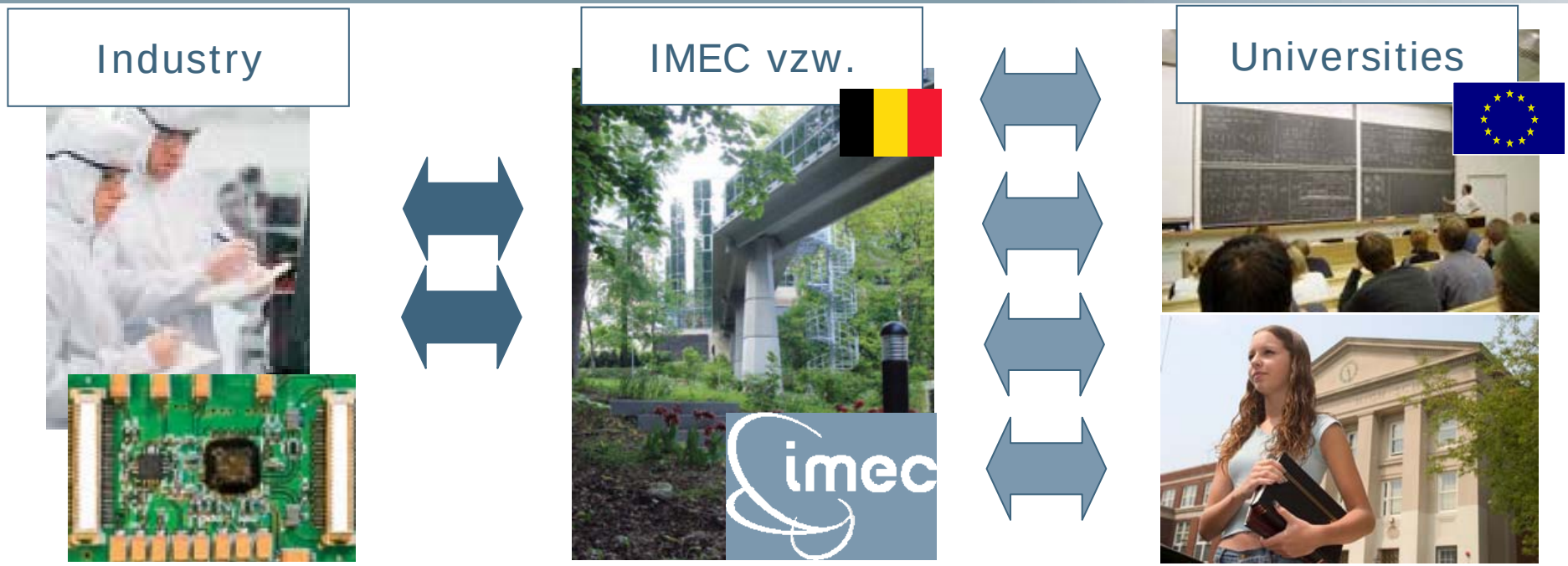
Research Network for System Level Design of Embedded Systems: Dynamic Memory Allocation Design Flow Case Study

S. Mamagkakis, D. Atienza, F. Catthoor,
D. Soudris and J. Mendias

Research Network for System Level Design of Embedded Systems

Motivation:
IMEC as a bridge between industry and academia



- Embedded system design solutions that are relevant for the industry
- Critical mass of researchers is needed to solve bigger, longer term problems
- Common problem definition and priorities are necessary

DACMA Marie-Curie star shaped network (PhD candidate collaboration in Europe)

- PhD candidates visit IMEC for a minimum of 3 months
- Their visits are fully funded by Marie-Curie scholarships
- They can have multiple visits (no more than half of their PhD duration)
- PhDs are trained by IMEC, collaborate with researchers and among themselves
- Their PhD focuses on a specific aspect of a bigger problem in Embedded System design
- Collaborative effort
- Each PhD contributes according to his specialty

Research network has been a success story

- Started in 1995 by F. Catthoor
- EC funding was later provided by DATMA Marie-Curie project
- EC Funding is extended with the DACMA Marie-Curie project (follow-up)
- More than 50 PhDs were trained and collaborated until now
- Each year ~10 PhDs visit IMEC for 3-4 months (40 person months per year)
- Absorbance rate 90%-100%

Training and collaboration of sandwich PhDs

- Training
  - Presentations from external prominent researchers every Friday (from industry and academia)
  - Presentations from internal IMEC-researchers every Tuesday
  - 3-day seminars about new design technologies/standards
  - Other seminars (e.g., public speaking, technical writing, etc.)
  - Daily supervision/training about the integrated design flow (terminology issues, shared problem perspective, etc.)
- Collaboration
  - With IMEC-researchers (~200 researchers for DESICS division)
  - With international residents (mainly industrial partners, see www.imec.be)
  - With other sandwich PhDs (from 15 Universities and 3 research centers)

Big gains for sandwich PhDs

- Training opportunities
- **Benefit from a big collection of specialists in every field of Embedded System design**
- Gain further qualifications through seminars
- **Extend their skills by collaboration with other PhD candidates with similar topics**
- Common Publications (e.g., more than 30 publications for 2005)
- International collaborations
- Networking opportunities
- **High industrial relevance**

Viral effect (dissemination continues in the home country of each student in their group)

What do the students think?

Overall success: very good

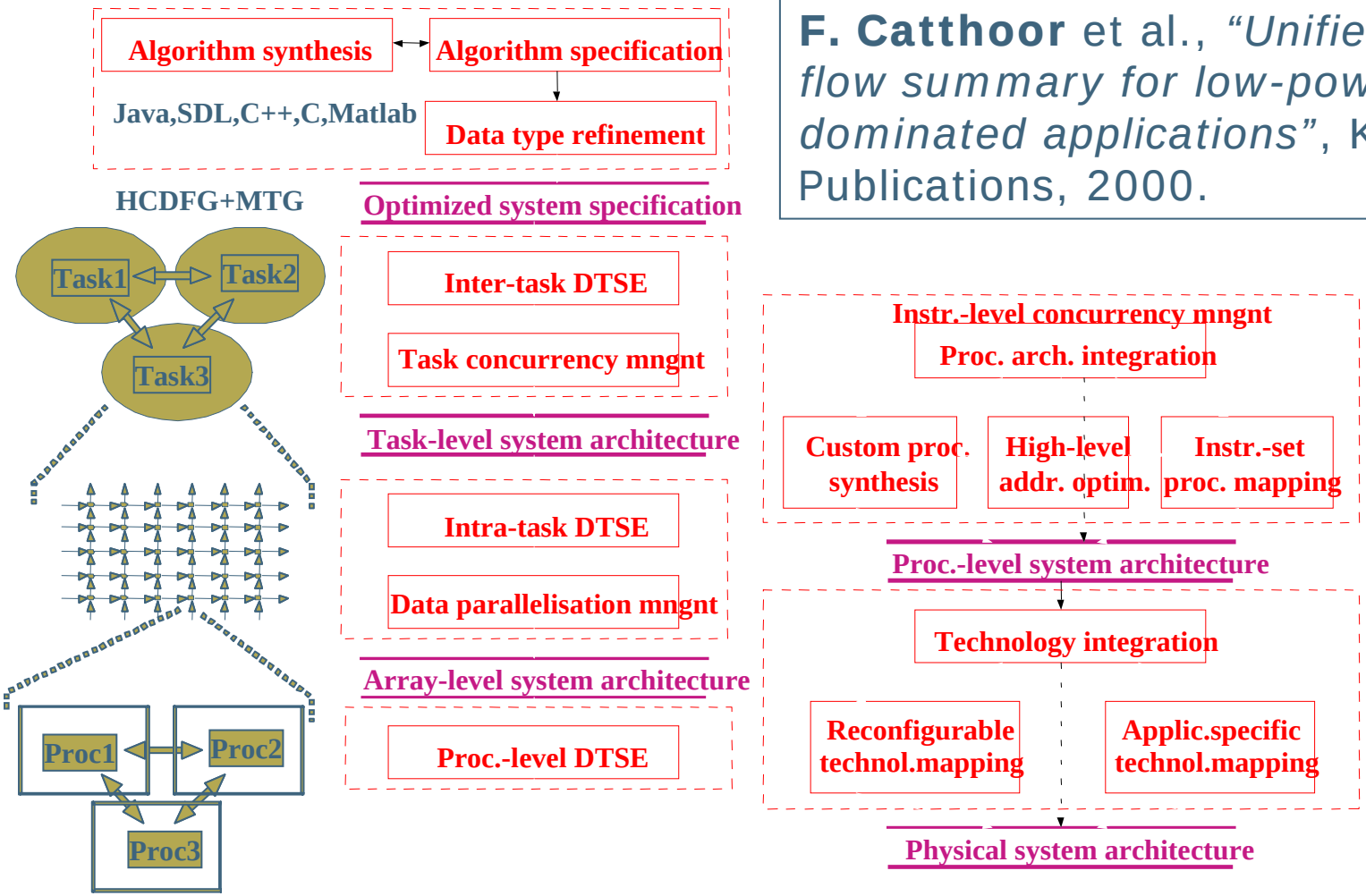
Research assessment:

- participation in meetings: good
- discussion of results: very good
- co-operation within team: very good
- co-operation with other host members: good
- originality: good
- capacity to develop skills: good
- productivity: very good
- communication skills: good
- group leader skills: good
- training/teaching: good

(average score of 10 students from the 2005 DACMA report)

Dynamic Memory Allocation Design Flow Case Study

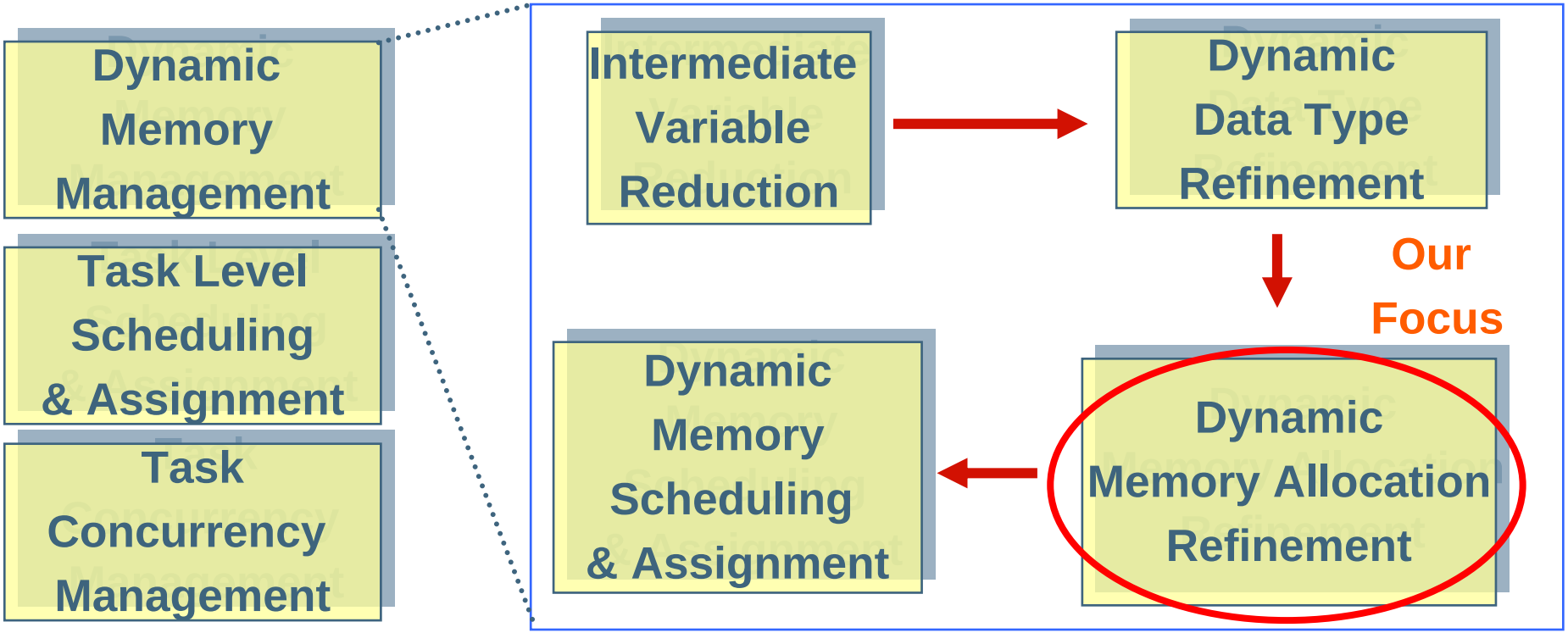
Unified meta-flow



Reference:

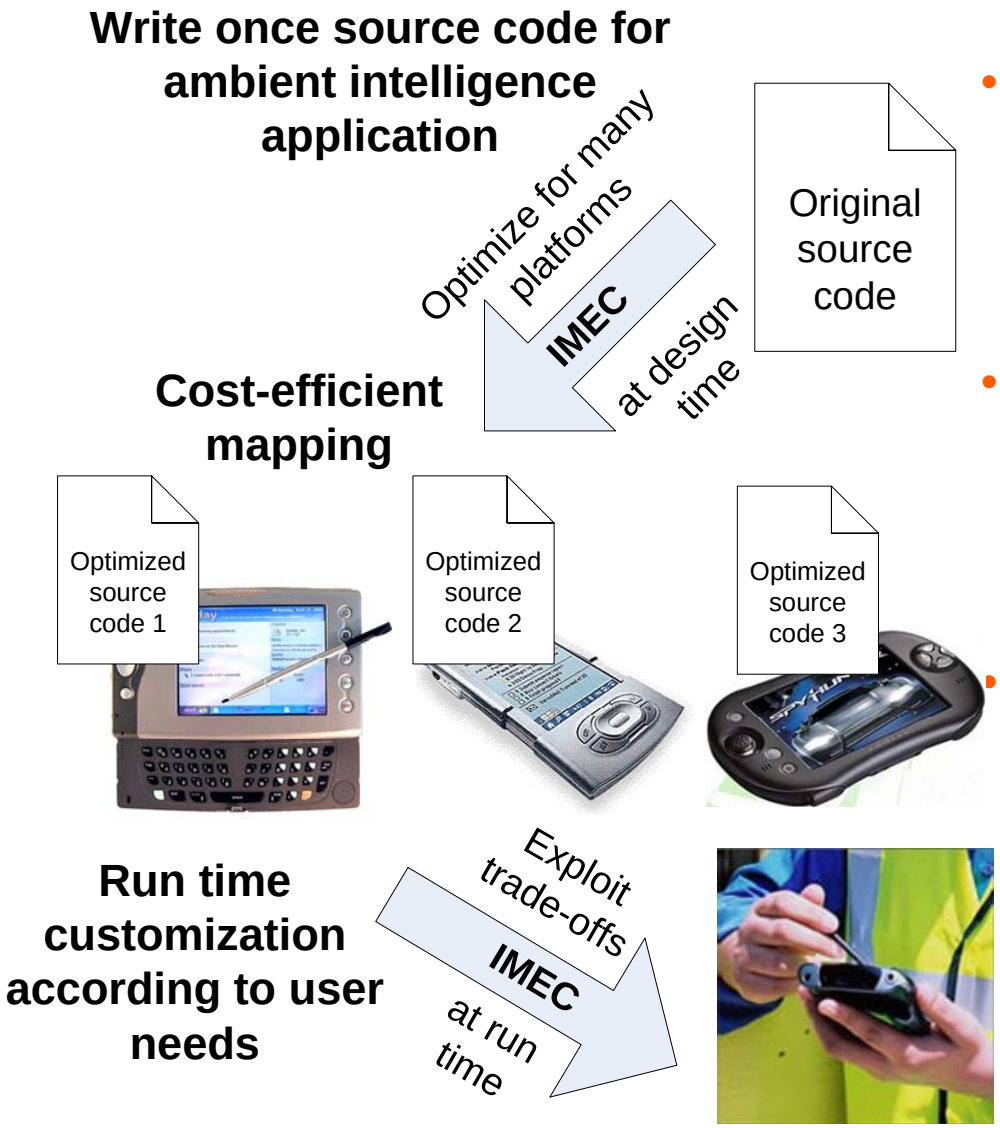
F. Catthoor et al., *"Unified meta-flow summary for low-power data-dominated applications"*, Kluwer Publications, 2000.

We focus on a specific part of the global design flow



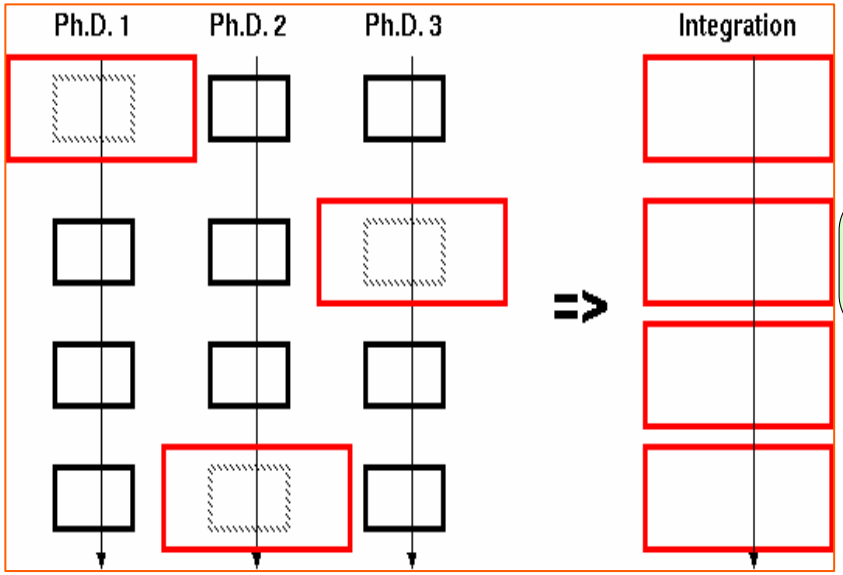
The focus of the collaboration was Dynamic Memory Allocation Refinement (malloc/free, garbage collection, new/delete)

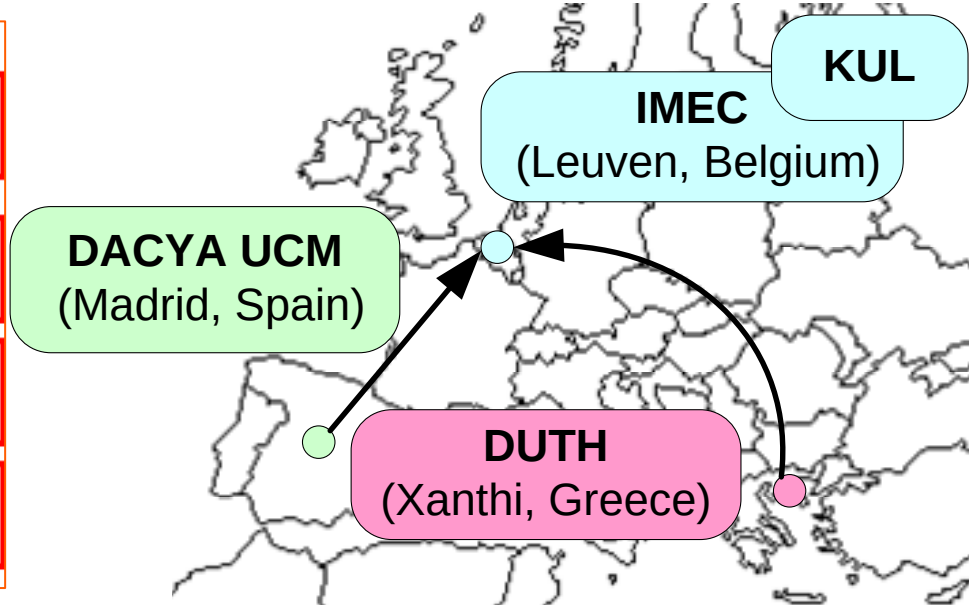
Our Motivation



- New **dynamic applications** of wireless multimedia terminals have increased needs of data transfer and storage
- Dynamic **memory management** of an embedded system is a **critical** part of the final design
- A successful design and implementation of a **customized** dynamic memory management **solution** guarantees lower energy consumption, small size and increased speed

Dynamic Memory (DM) Allocation Refinement Collaboration

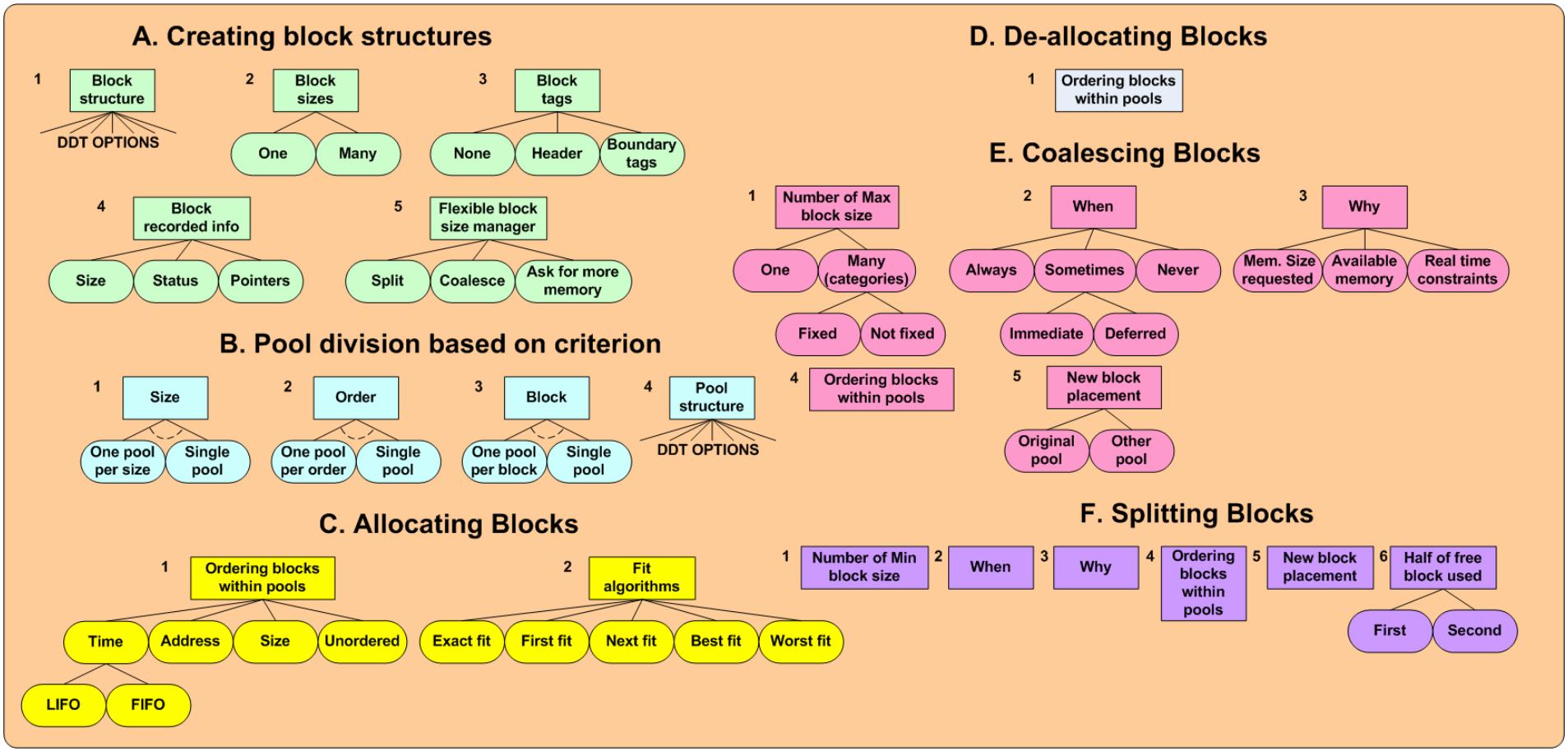




3 PhD candidates were involved:

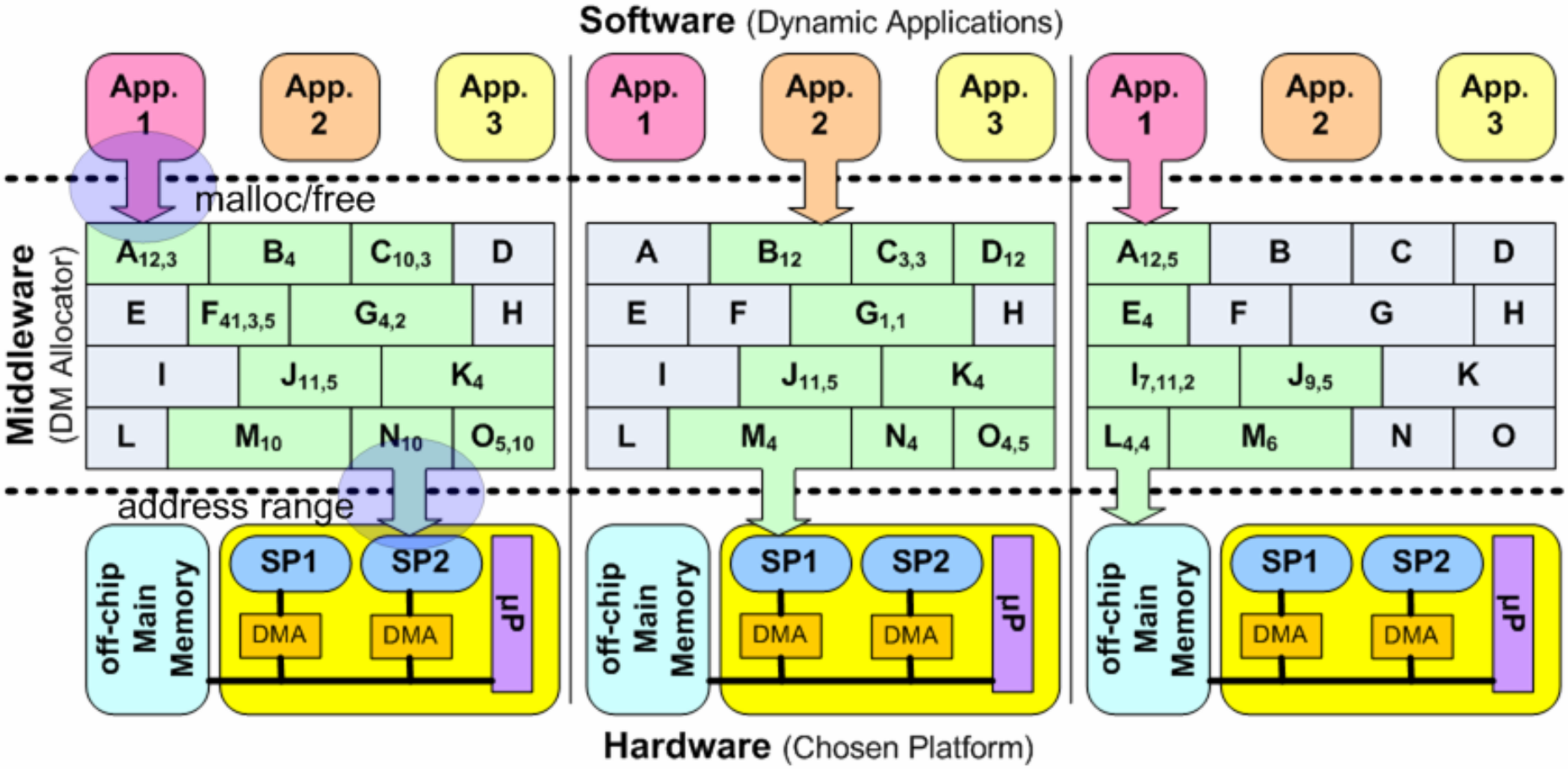
- S. Mamagkakis (Greece)
- D. Atienza (Spain)
- M. Leeman (Belgium)

Huge design space of available solutions



With the combination of proposed solutions, we are able to create millions of ultra-customized DM allocators

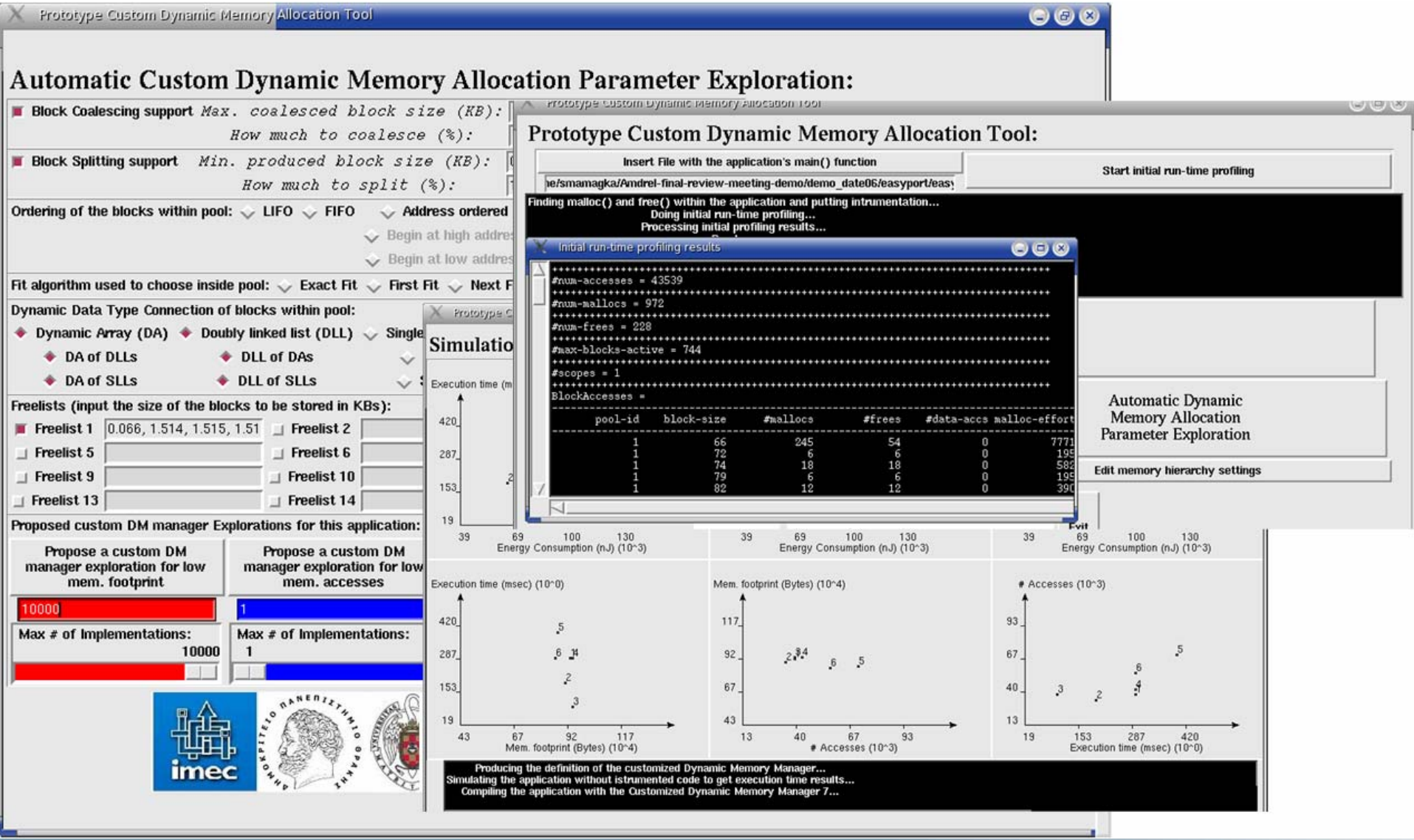
Super-customized DM allocators (according to SW application and HW platform)



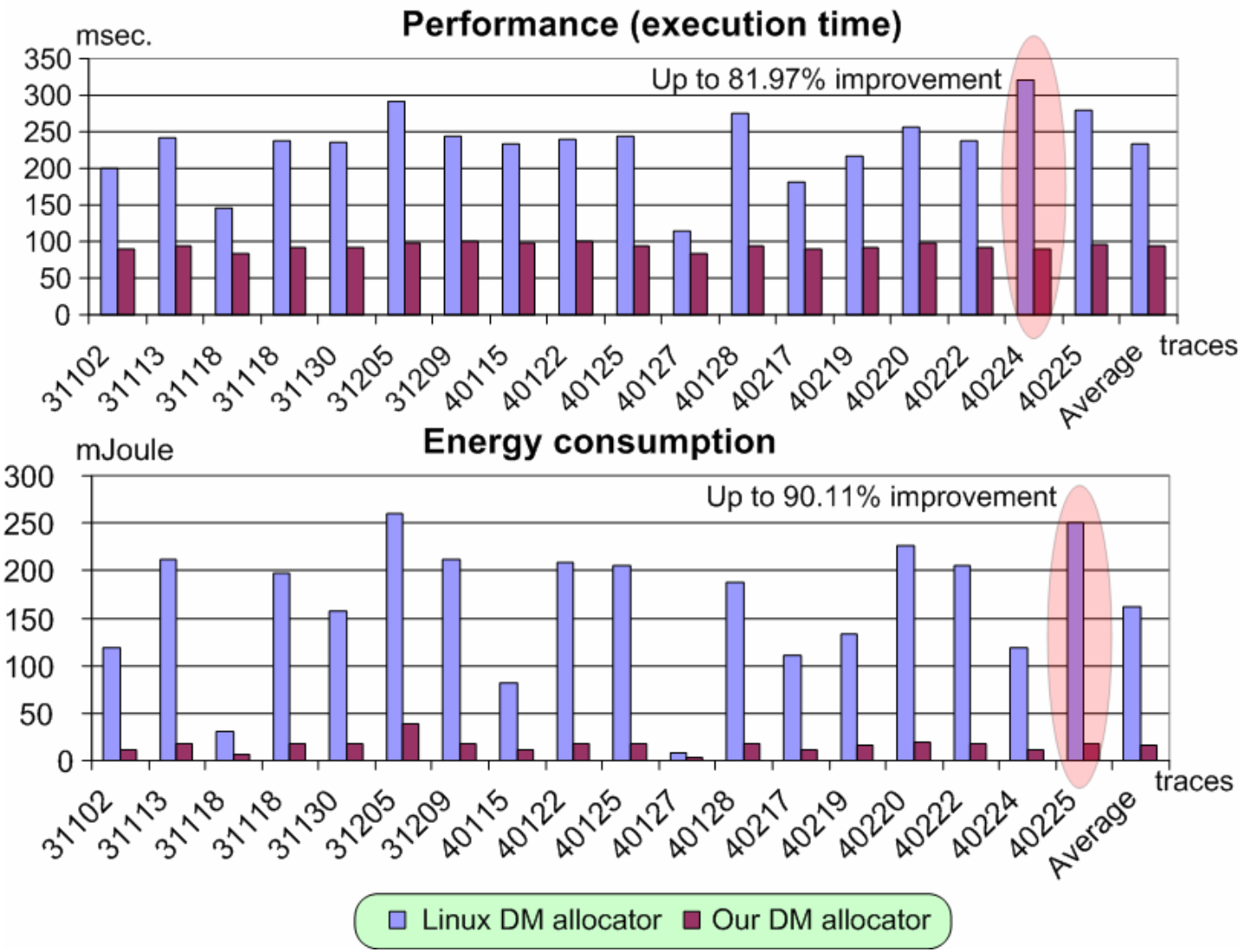
Customization of DM allocators:

- According to applications (software)
- According to memory hierarchy (hardware)

Our Tool for automatic exploration of DM allocator solution



Very promising results (802.11b example)



Dissemination:
of Publications of the partners the last 4 years

- 3 internal technical reports
- 1 Book Chapter
- 6 Journals
  - 1 IEEE
  - 1 ACM
  - 1 IEE
  - 3 Elsevier
- 19 Conference Papers (eg., 4 in DATE conf., 1 in DAC conf. - candidate for best paper award)
- Currently we are preparing a book about 'Dynamic Memory Management'

Conclusions

- Collaboration can solve bigger, longer term problems in Embedded System Design
- It requires an initial investment in training
- There is a small management/integration overhead
- The final results are very promising and justify the investment

IMEC's 'sandwich PhD' model can be re-used by other institutes around the world!

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