Benchmark Problems for Computational Efficiency of Rigid Multibody System Dynamics

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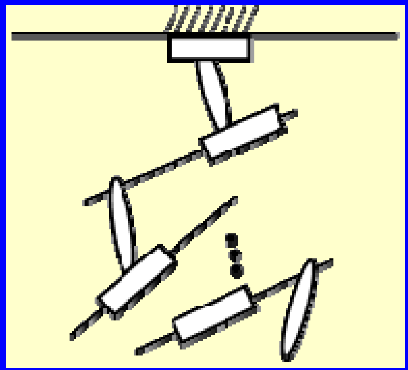
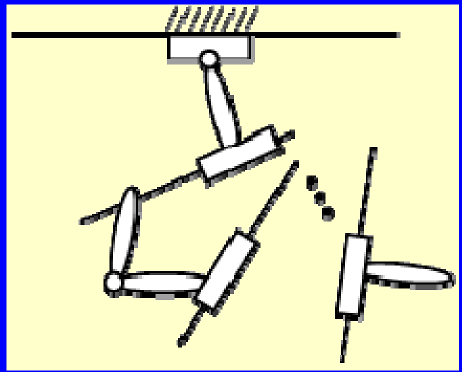
Concept of benchmarking

- Benchmarks should test the capability of methods
- Benchmarks are constructed based on the knowledge of drawbacks of methods
- Benchmarks include the expert knowledge of methods

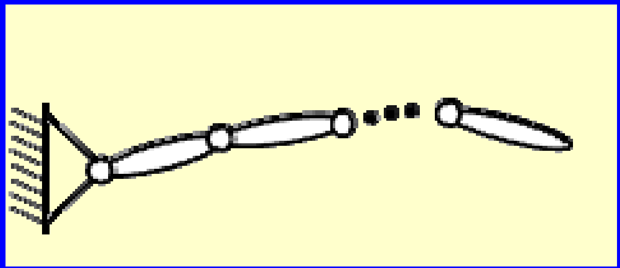
Two multibody benchmark classes

- Real dynamic problem



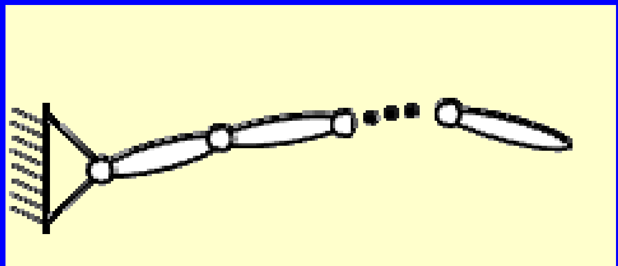


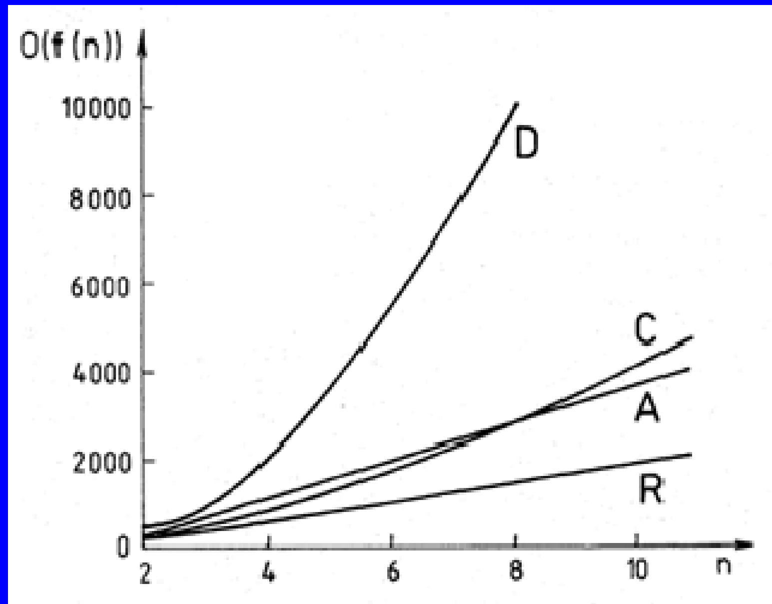
- Principal computational complexity



Open-loop rigid multibody benchmark

- Traditional rigid multibody benchmarks

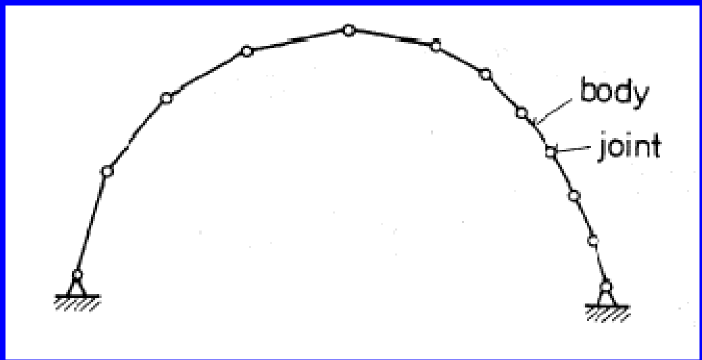


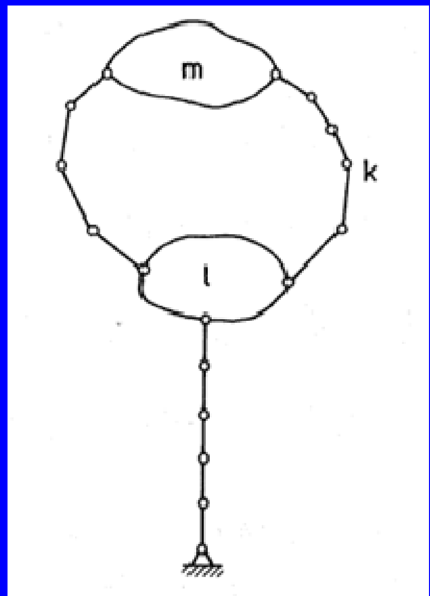


- D – direct
- A – recursive O(n)
- C – recursive O(n^2)
- R – residual

Recursive methods for closed-loop rigid multibody system

- Computational complexity of MBS with loops should be O(loops^3)
- Parametric method enables to solve MBS with external kinematic loop in O(loops)
- Internal kinematic loop is the problem





Benchmarks for rigid multibody systems with kinematical loops

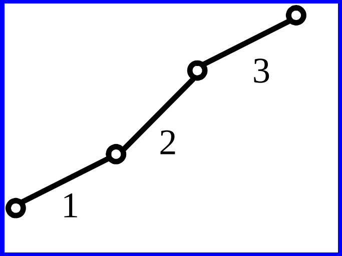
- Rigid multibody systems with 1 DOF and increasing number of internal kinematical loops with the increasing minimum length
- Existence of such multibody system for any minimum loop length is unsolved

Graph methods for description of Multibody Systems

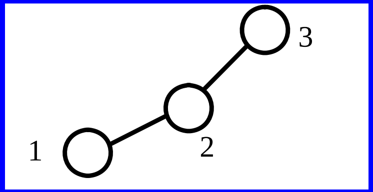
Two ideal objects: rigid body and kinematic joint (kin. pair)

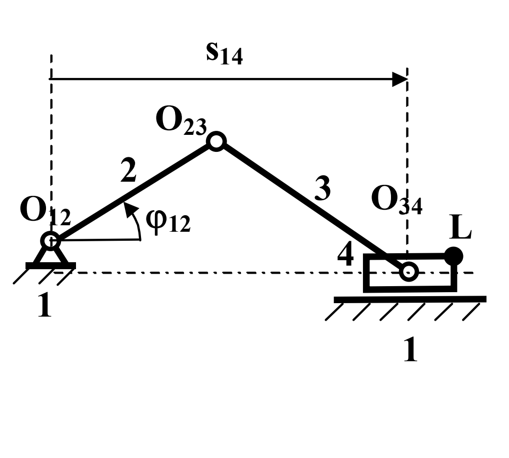
<u>body</u>   <u>kinematical joint (KJ, kinematic pair)</u>

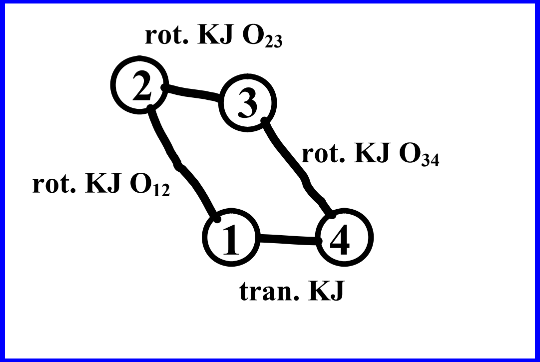
Kin.scheme   edge   vertex



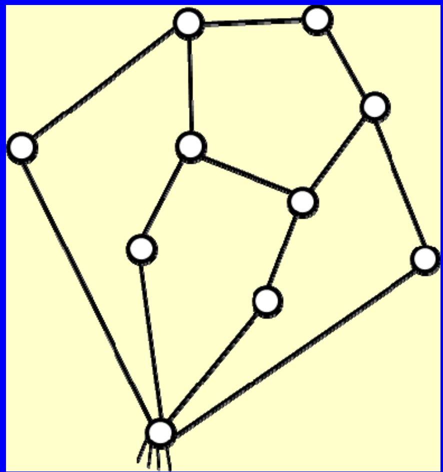
Graph   vertex edge

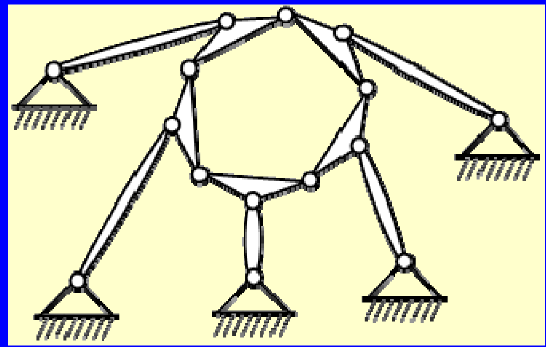




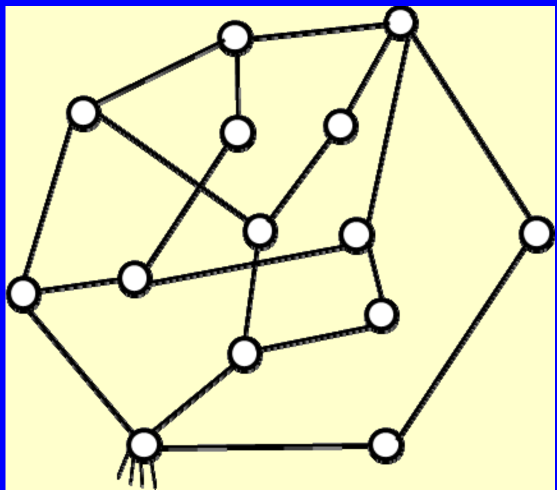


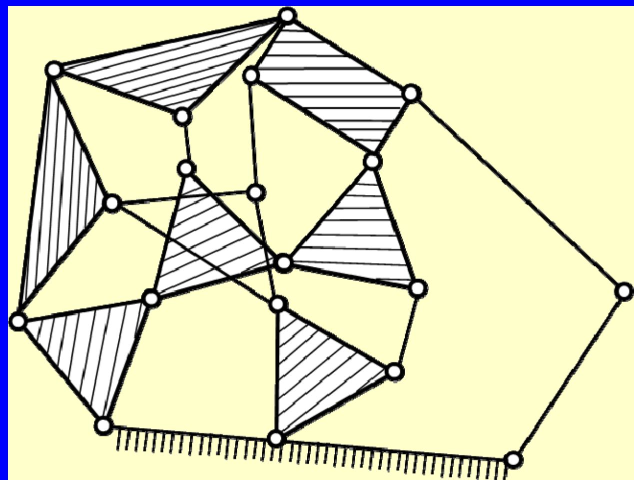
Benchmarks – 1 DOF





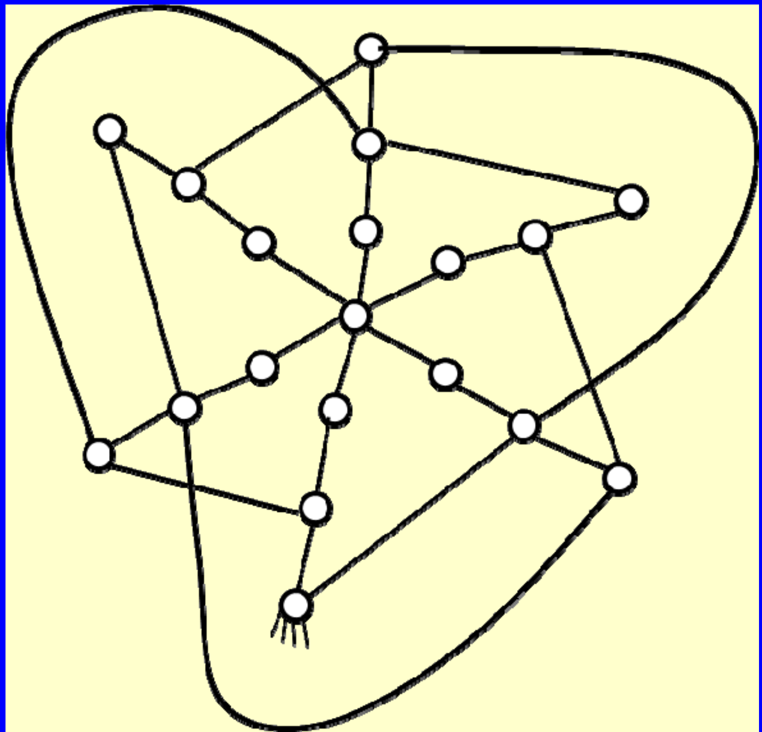
Lmin = 4





Lmin = 5

Benchmarks cont.



Lmin = 6

…

Lmin = 67

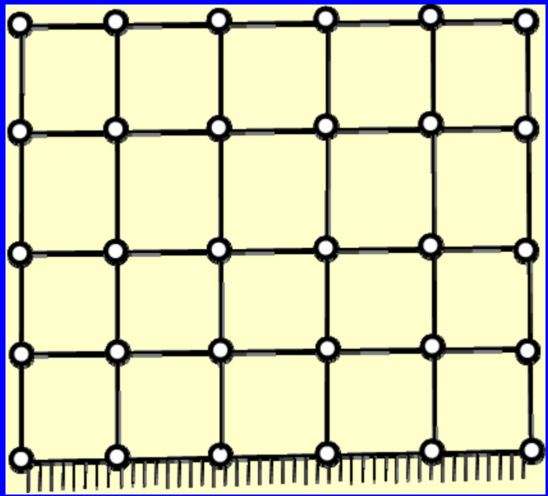
???

Different processor structure

- Theory developed for single processor
- Is it valid also for multiple parallel processors?
- Investigation of parallelized multibody formalisms on the benchmarks necessary
- Current results – challenge for parallel processors is the amount of interconnection of bodies = closed loop multibody benchmarks

Not so severe but more realistic?

- Benchmark proposed in Torres-Moreno et al. paper from session on Efficient simulation and real-time applications



Lmin = 4

- Would material model or MBS structure require even more interconnections?

Conclusions

- Principal computational complexity - rigid multibody benchmarks
- Traditional open loop multibody benchamrks
- New closed loop multibody benchmarks
- Difference between serial/parallel formalisms?

Thank you for your kind attention