Vom Zeitbeiwertverfahren zum Mehrprozessorsystem

Über den Wandel der Methoden in der Kanalnetzberechnung

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Wer sind Wir?

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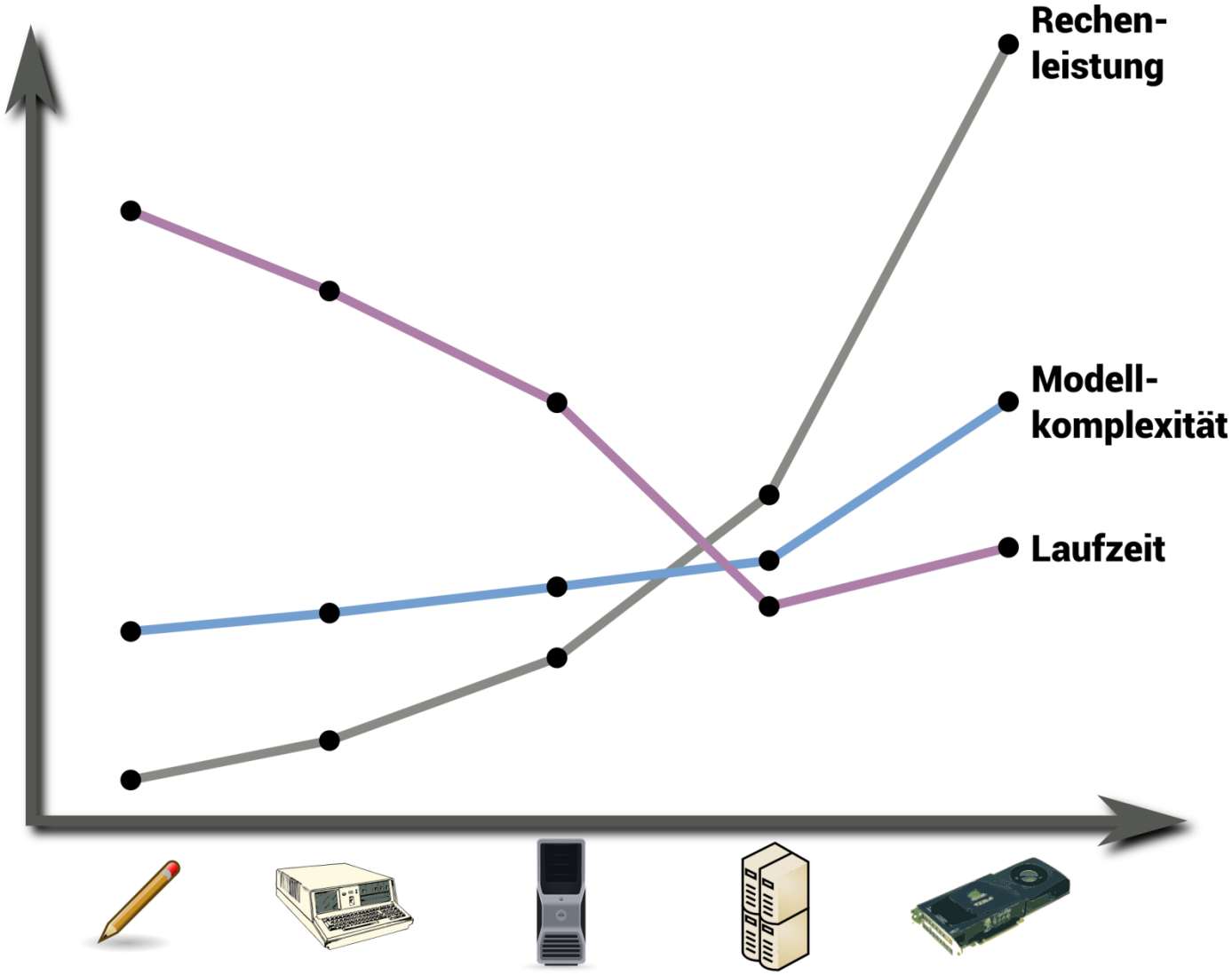
Überblick



Überblick

- Vergangenheit
  - Modellierung
  - Block & Bleistift
  - Computerrevolution
- Gegenwart
- Zukunft

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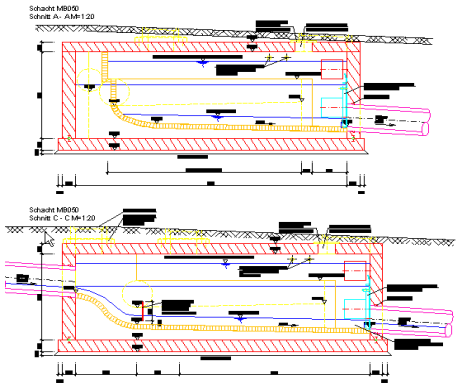
Modellierung I

"Reality"



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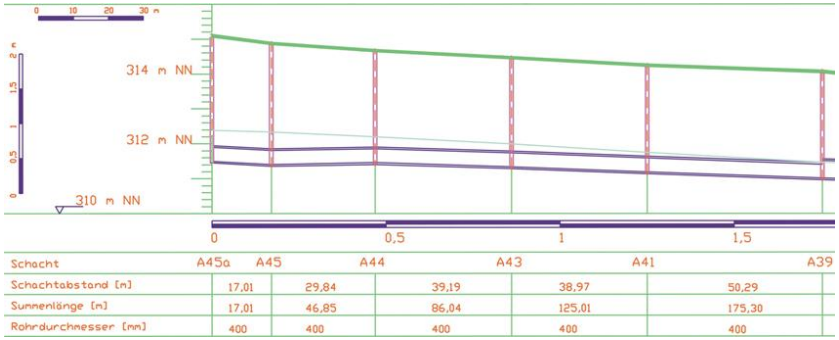
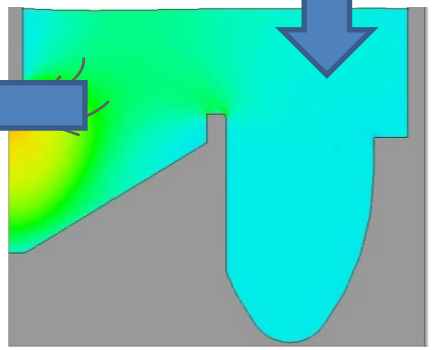
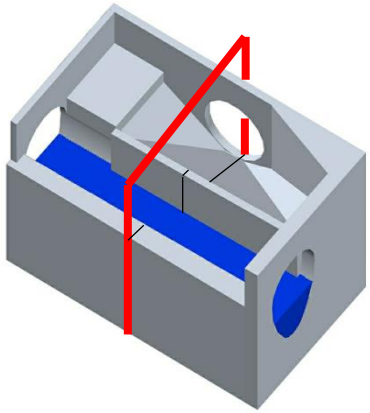






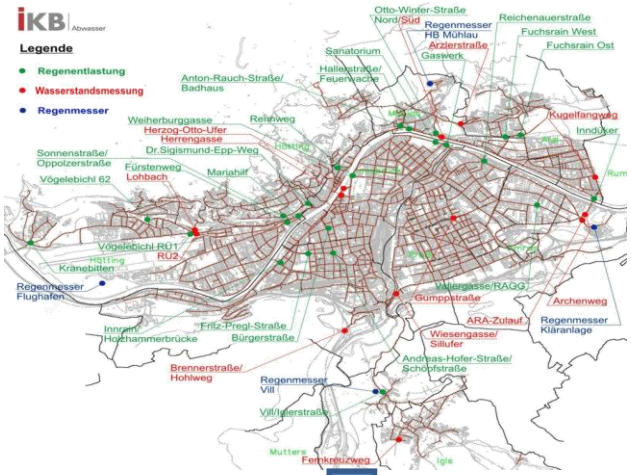
Result: Model Behaviour

→ Dimensioning

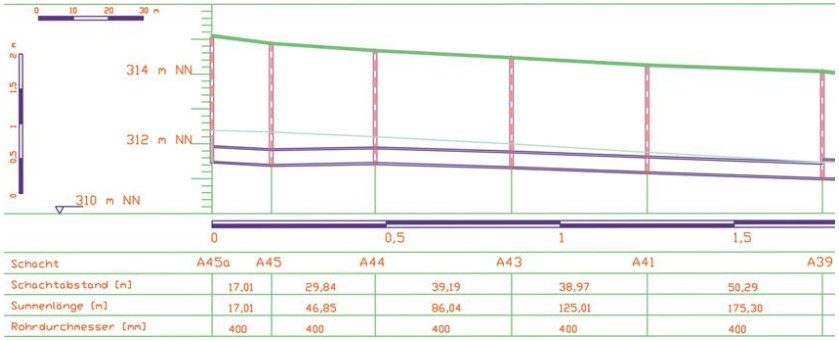
MODEL - Simulation

Modellierung II

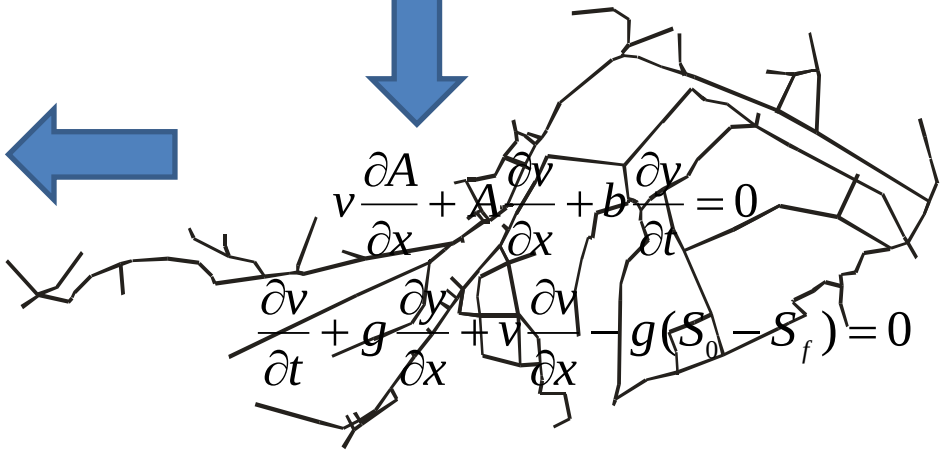
“Reality”



DATA



Schacht	A45a	A45	A44	A43	A41	A39
Schachtabstand [m]	17,01	29,84	39,19	38,97	50,29	
Sunnenlänge [m]	17,01	46,85	86,04	125,01	175,30	
Rohrdurchmesser [mm]	400	400	400	400	400	



$$v\frac{\partial A}{\partial x} + A\frac{\partial v}{\partial x} + b\frac{\partial y}{\partial t} = 0$$

$$\frac{\partial v}{\partial t} + g\frac{\partial y}{\partial x} + v\frac{\partial v}{\partial x} - g(S_0 - S_f) = 0$$

MODEL - Simulation

Result: Model Behaviour

→ Dimensioning

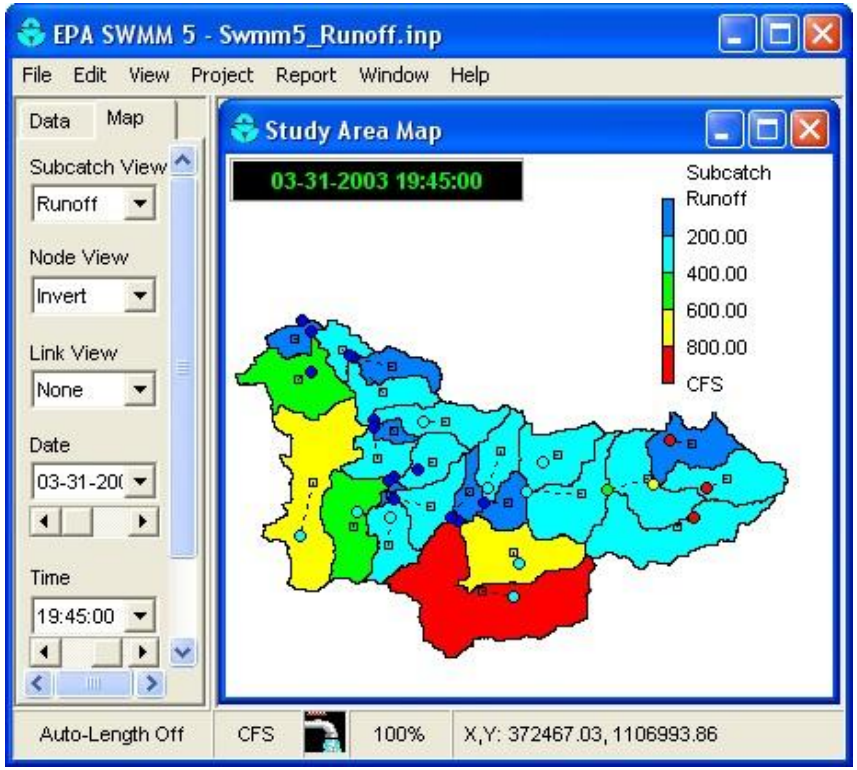
Block & Bleistift

Nr.	$A_{E,k}$ (ha)	ψ (-)	A_{red} (ha)	Σ A_{red} (ha)	L (m)	v (m/s)	t (min)	Σt (min)	φ (-)	Q_R (l/s)
S7	8,7	0,3	2,6	2,6	212	1,0	3,5	8,5	1,64	640
S6	11,0	0,3	3,3	3,3	278	1,0	4,6	9,6	1,64	812
S5	5,2	0,5	2,6	8,5	192	1,0	3,2	12,8	1,43	1823
S4	6,2	0,5	3,1	11,6	191	1,0	3,2	16,0	1,25	2175

Computerrevolution

- <u>Hydrodynamische Werkzeuge</u>

- Hydrologische Werkzeuge



Computerrevolution

- Hydrodynamische Werkzeuge

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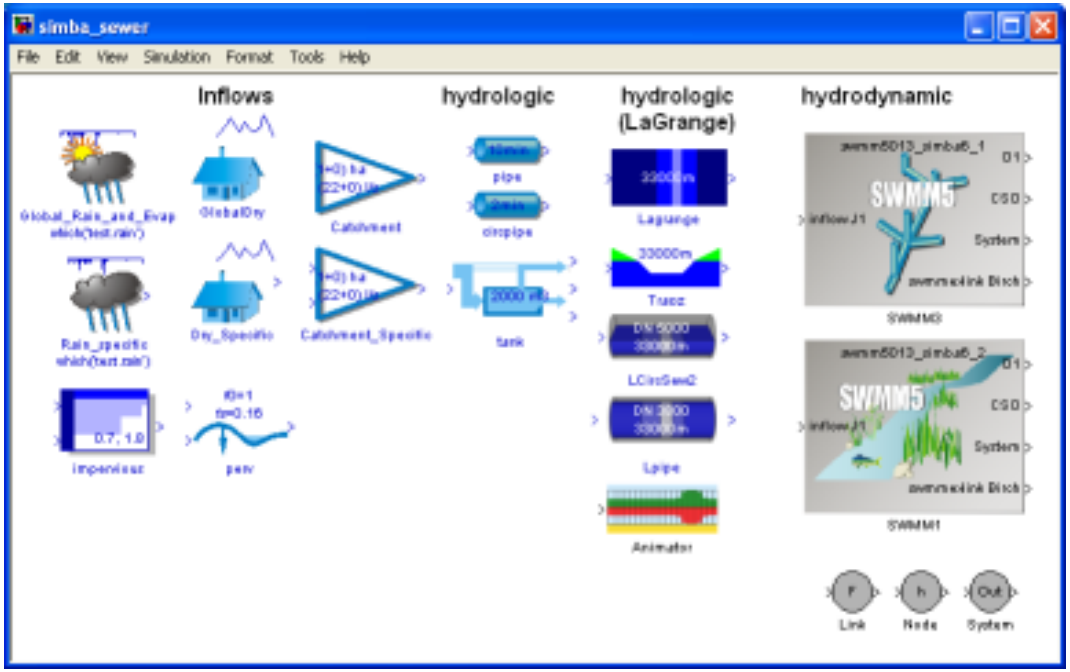

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Überblick

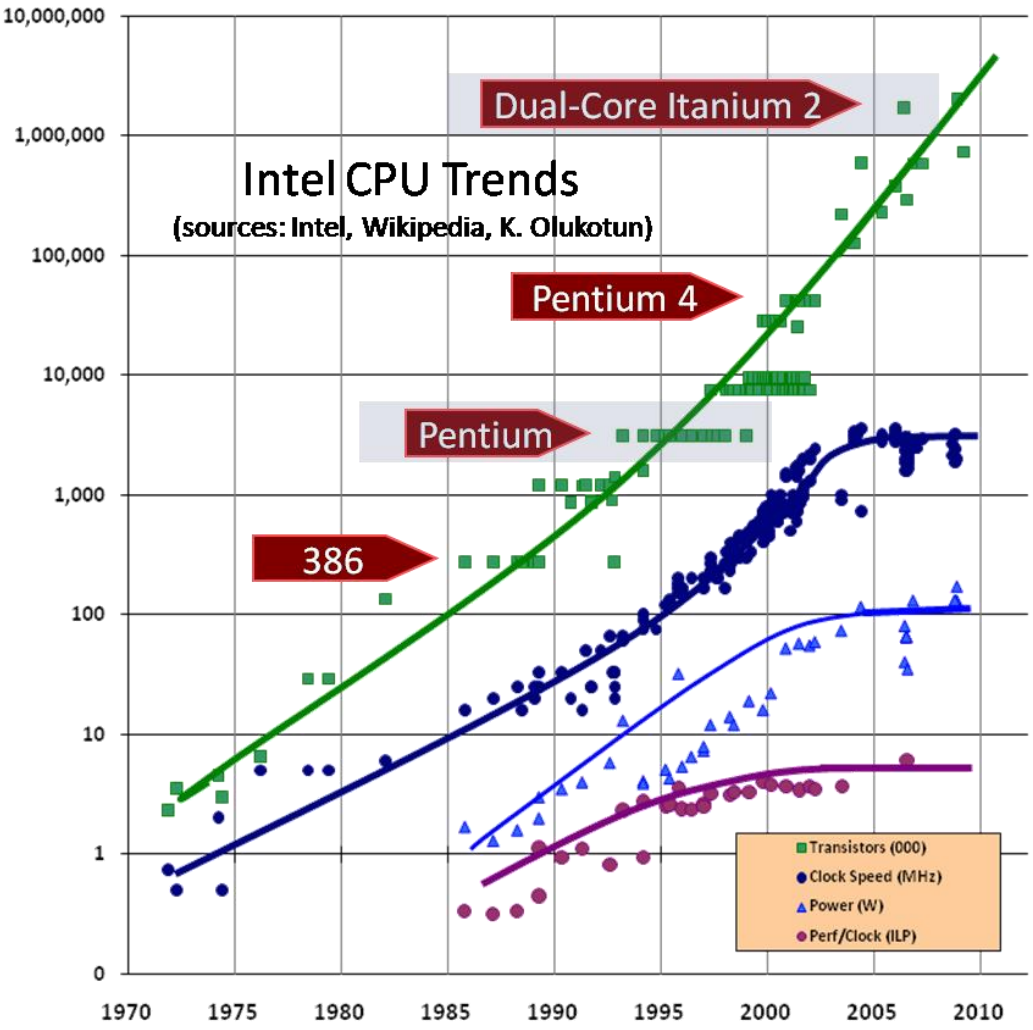
- Vergangenheit

- Gegenwart
  - Mehrkernrevolution
  - CityDrain3
  - Parallel SWMM

- Zukunft

Mehrkernrevolution

- "The Free Lunch is over"
- Parallele Datenverarbeitung
- Herausforderungen



Mehrkernrevolution

- “The Free Lunch is over”

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- Herausforderungen

Mehrkernrevolution

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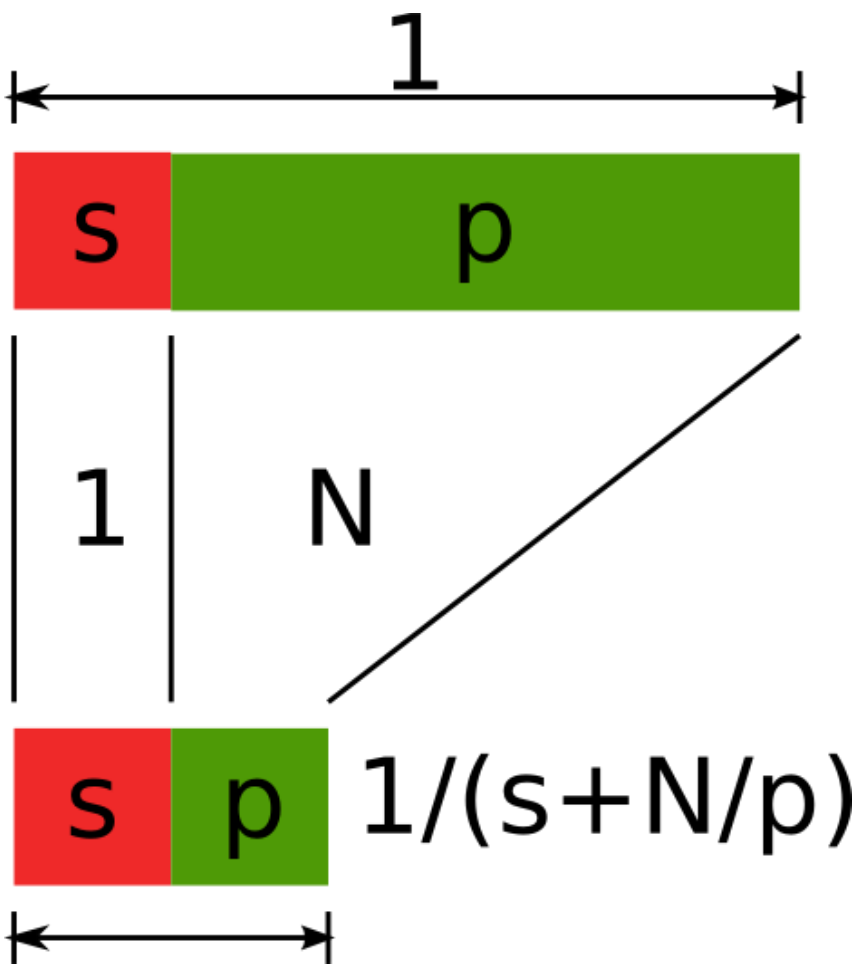

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Mehrkernrevolution

- “The Free Lunch is over”

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- <u>Herausforderungen</u>

Mehrkernrevolution

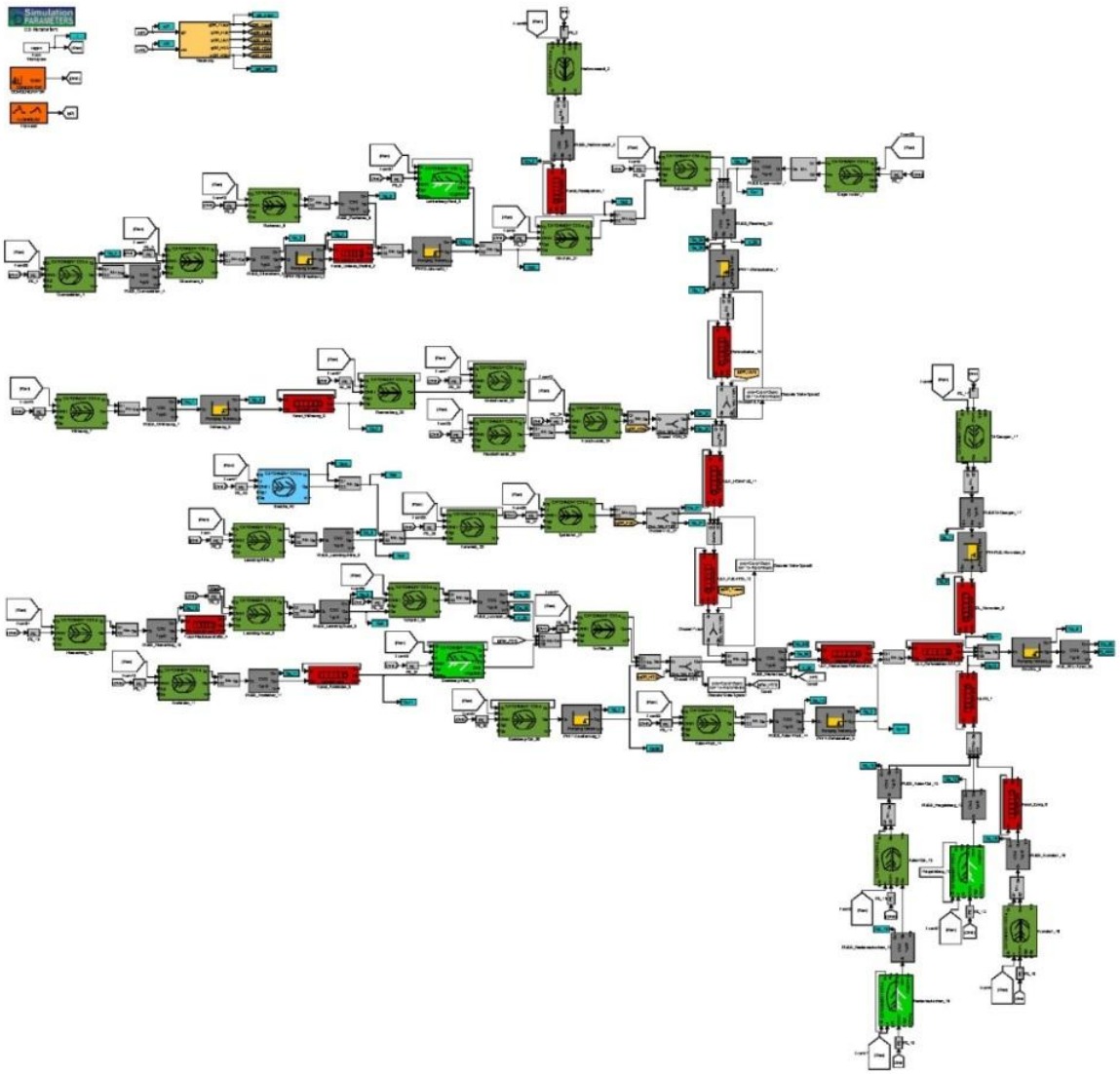
- “The Free Lunch is over”

- Parallele Datenverarbeitung

- <u>Herausforderungen</u>

CityDrain3

- <u>CITYDRAIN II</u>
- Rewrite/Design
- Parallele Algorithmen
- Resultate



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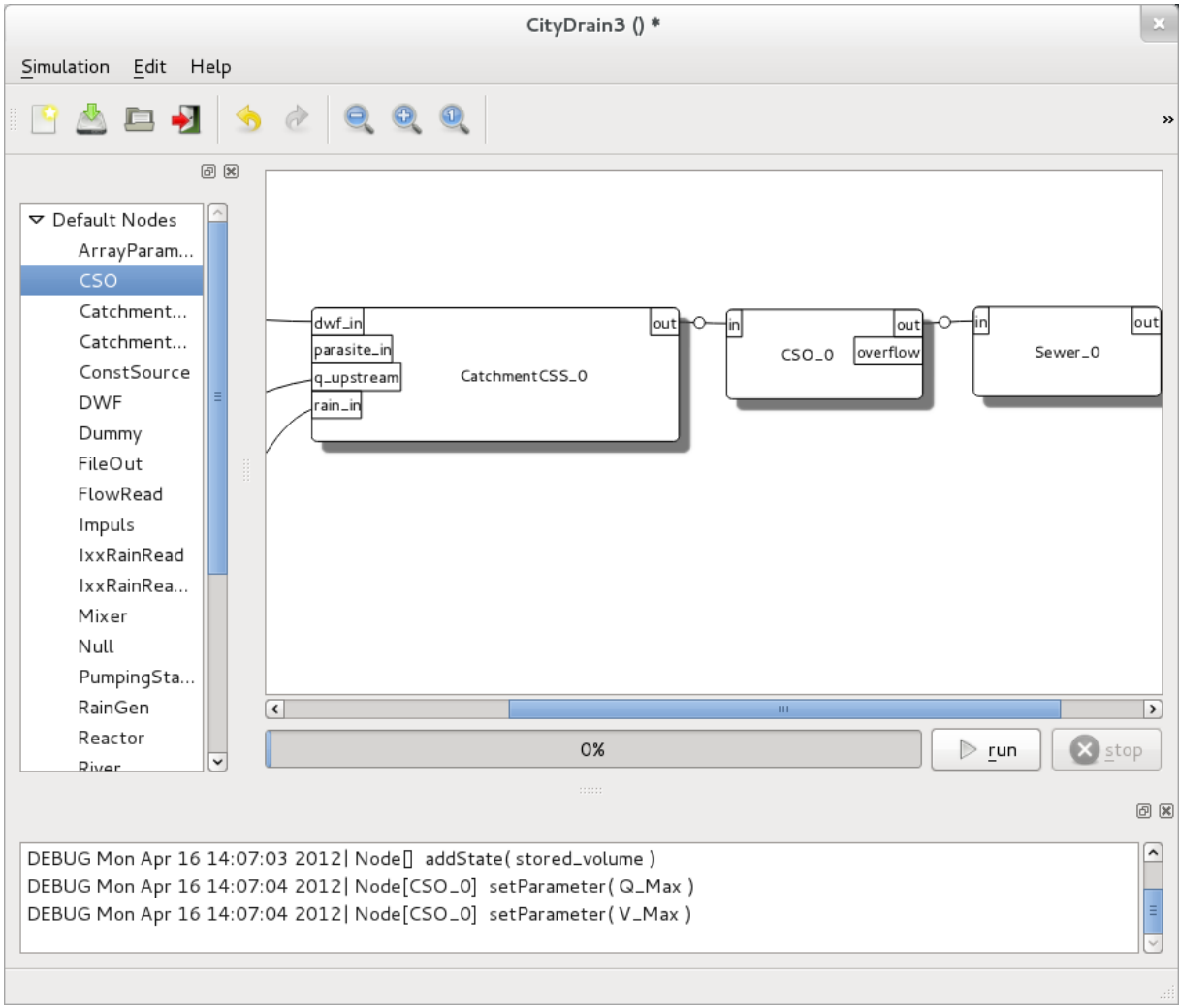

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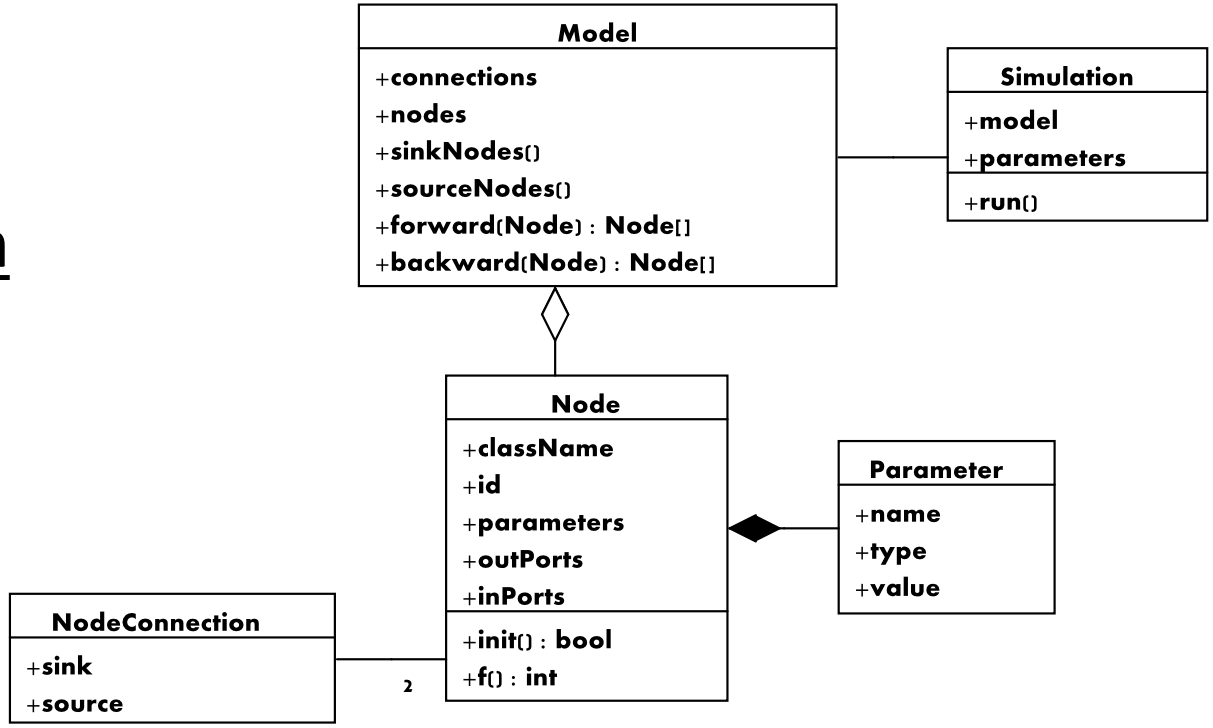

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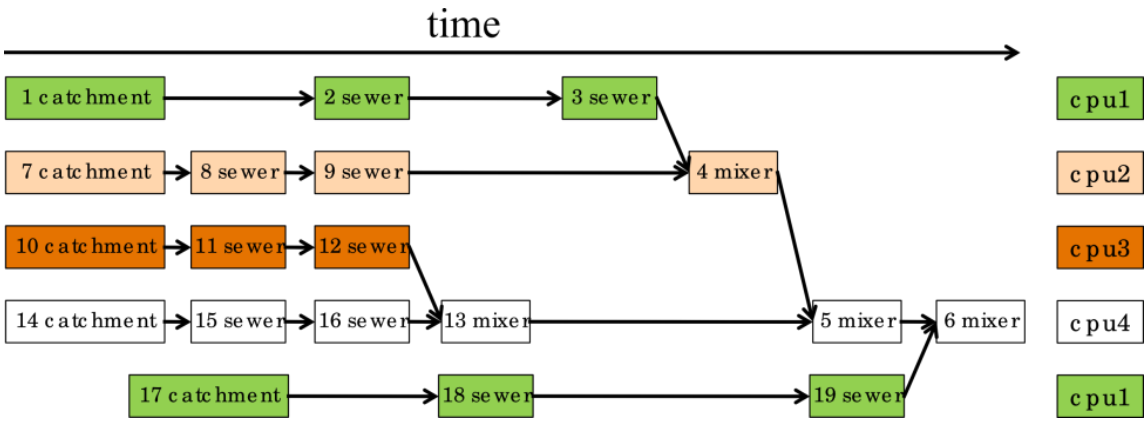

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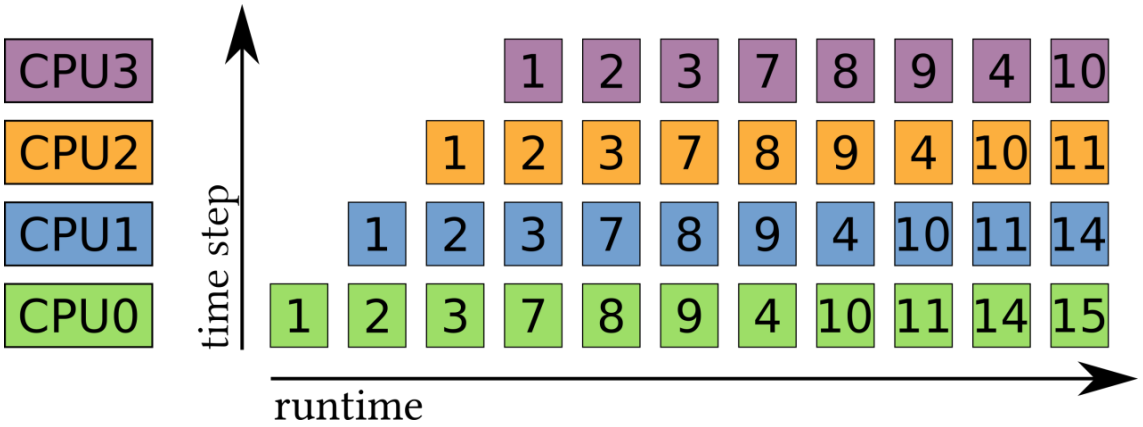

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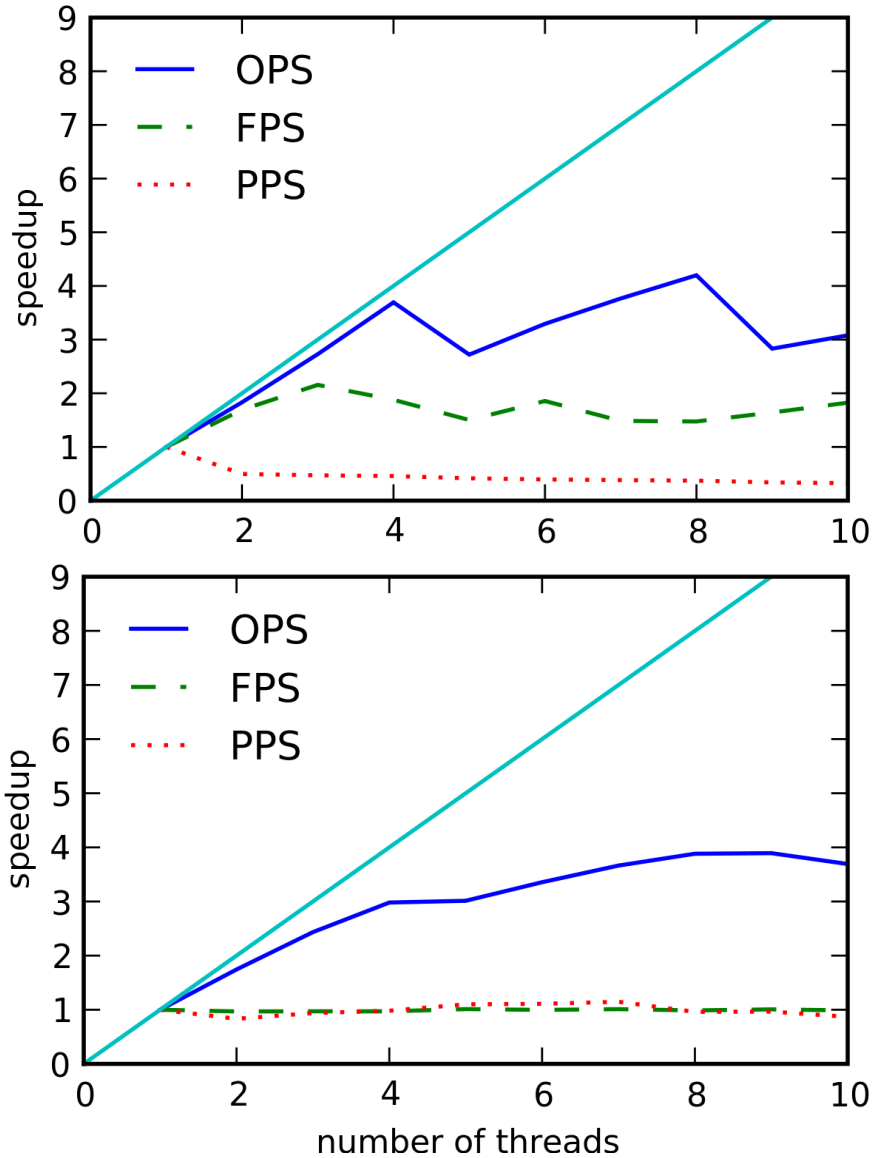

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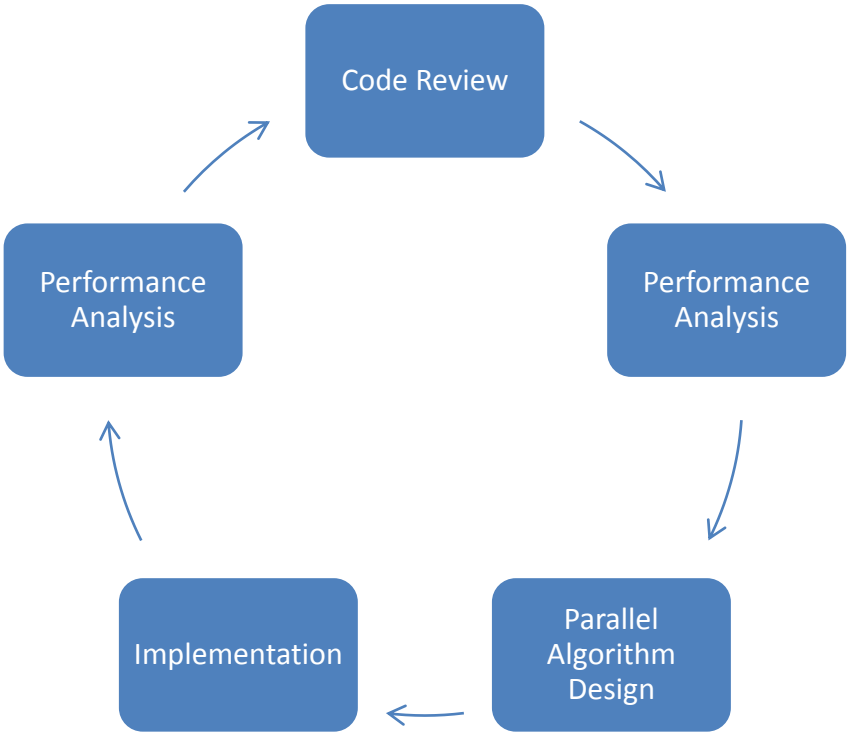
Parallel SWMM

- <u>Voraussetzungen</u>
- Implementierung
- Resultate

- 1971
- Open Source
- Weit verbreitet
- Wenig Codeänderungen
- Unbekannter Code

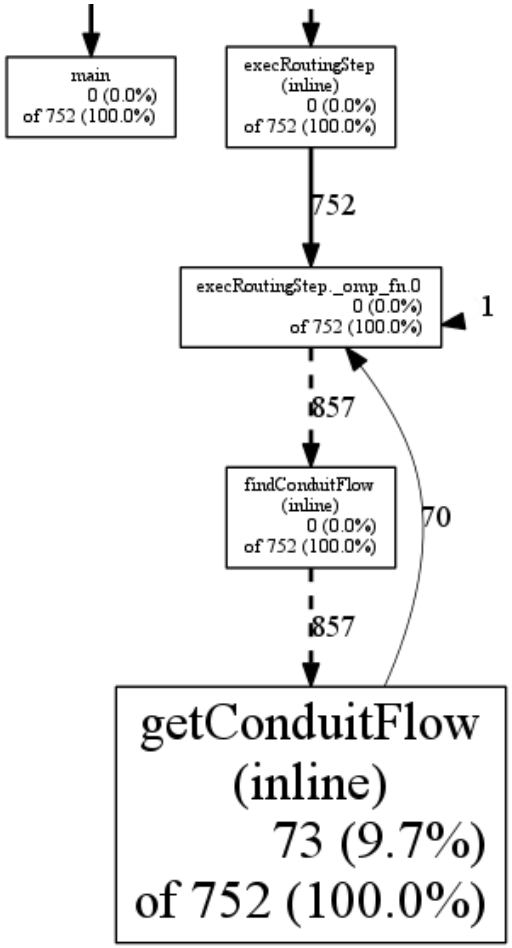
Parallel SWMM

- Voraussetzungen
- <u>Implementierung</u>
- Resultate



Parallel SWMM

- Voraussetzungen
- <u>Implementierung</u>
- Resultate



Parallel SWMM

- Voraussetzungen
- <u>Implementierung</u>
- Resultate

```
257  int execRoutingStep(int links[], double dt)
258  //
259  //  Input:   links = array of link indexes
260  //           dt    = time step (sec)
261  //  Output:  none
262  //  Purpose: solves momentum eq. in links and continuity eq. at nodes
263  //           over specified time step.
264  //
265  {
266      int    i;                          // node or link index
267      int    Converged;
268      double yOld;                       // old node depth (ft)
269
270  #pragma omp parallel
271      {
272      // --- re-initialize state of each node
273  #pragma omp for private(i)
274      for ( i = 0; i < Nobjects[NODE]; i++ ) initNodeState(i);
275      Converged = TRUE;
276
277      // --- find new flows in conduit links and non-conduit links
278  #pragma omp for private(i) firstprivate(dt)
279      for ( i=0; i<Nobjects[LINK]; i++) findConduitFlow(links[i], dt);
280
281  #pragma omp for private(i) firstprivate(dt)
282      for ( i=0; i<Nobjects[LINK]; i++) findNonConduitFlow(links[i], dt);
283
284      // --- compute outfall depths based on flow in connecting link
285  #pragma omp for private(i)
286      for ( i = 0; i < Nobjects[LINK]; i++ ) link_setOutfallDepth(i);
287
288      // --- compute new depth for all non-outfall nodes and determine if
289      //     depth change from previous iteration is below tolerance
290  #pragma omp for reduction(&&:Converged) private(yOld, i) firstprivate(dt)
291      for ( i = 0; i < Nobjects[NODE]; i++ )
292      {
293          if ( Node[i].type == OUTFALL ) continue;
294          yOld = Node[i].newDepth;
295          setNodeDepth(i, dt);
```

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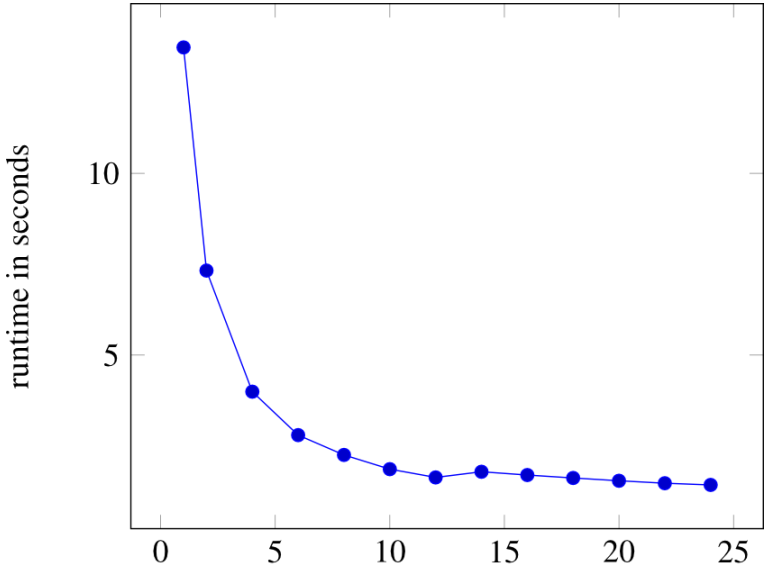
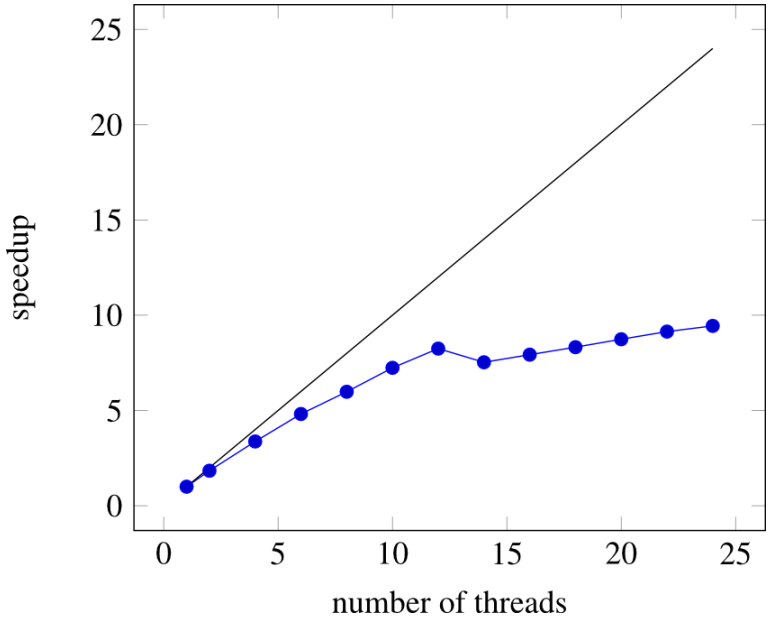
Parallel SWMM

- Voraussetzungen
- Implementierung
- <u>Resultate</u>



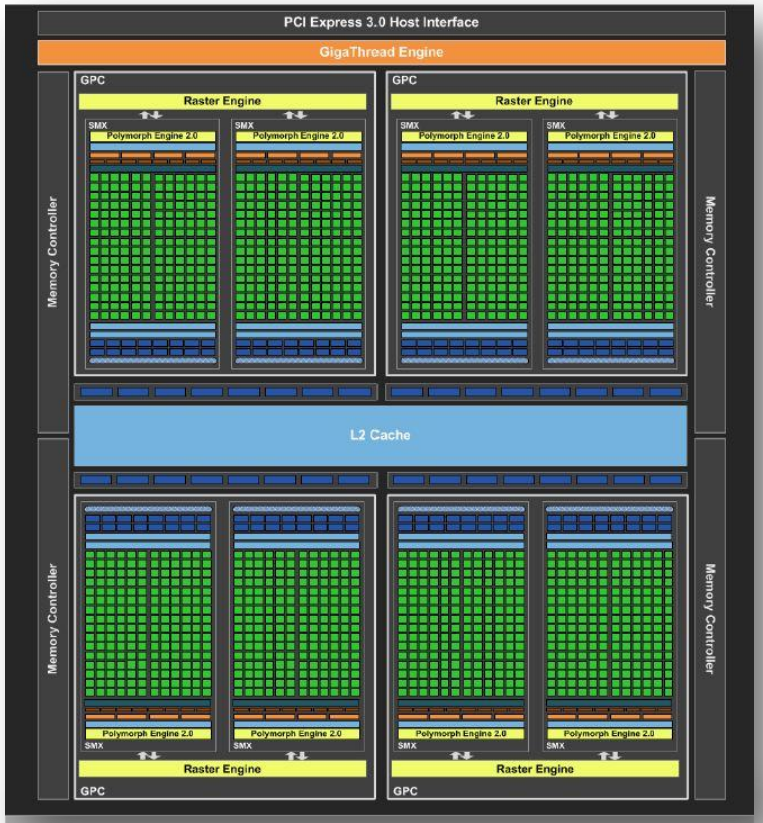


Überblick

- Vergangenheit

- Gegenwart
- Zukunft
  - Vielkernrechner
  - SPH

Vielkernrechner



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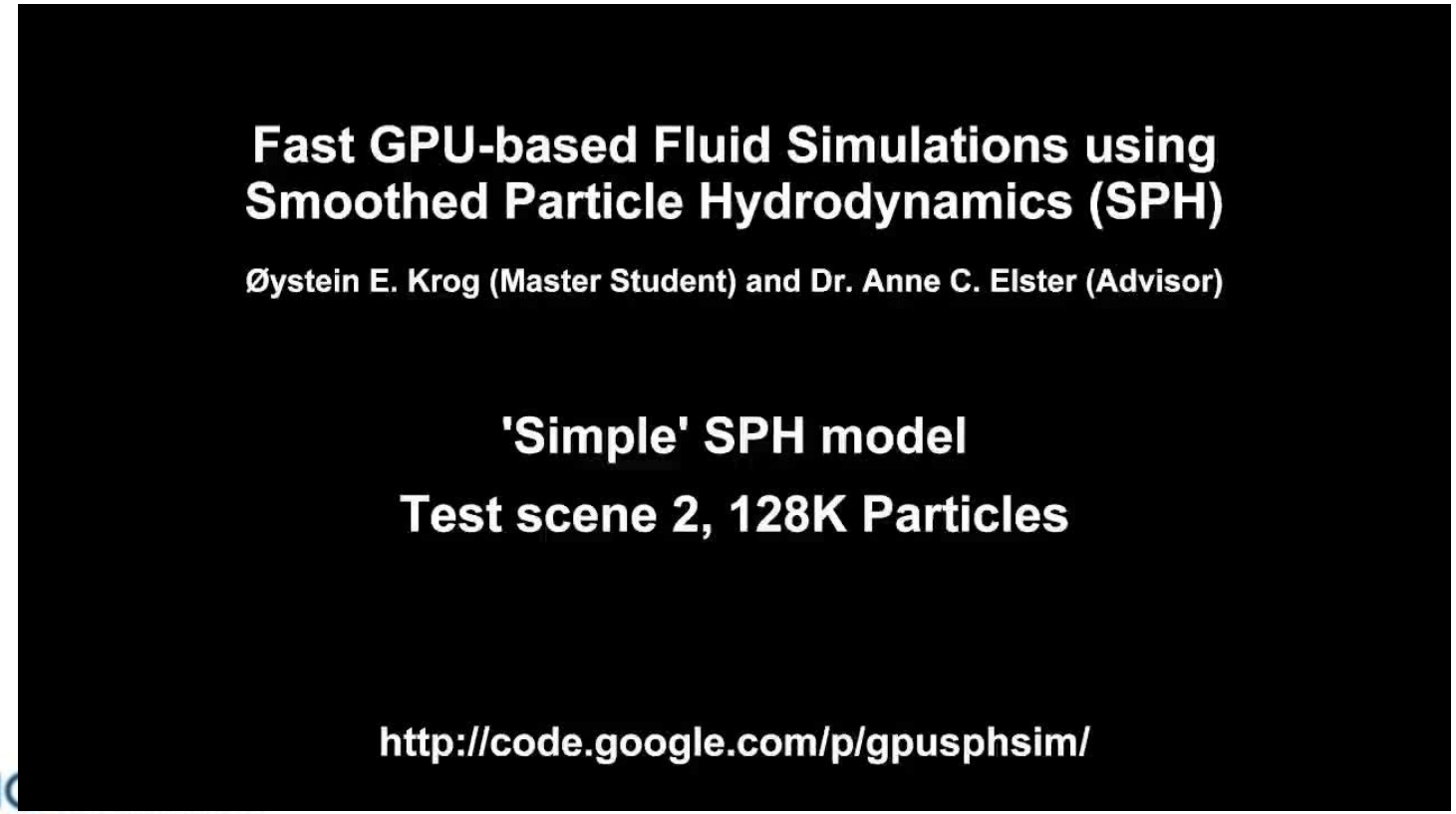
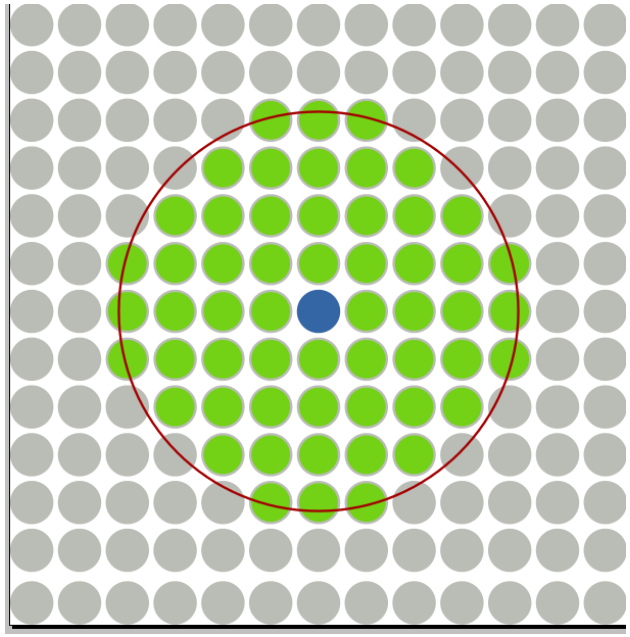
Smoothed Particle Hydrodynamics

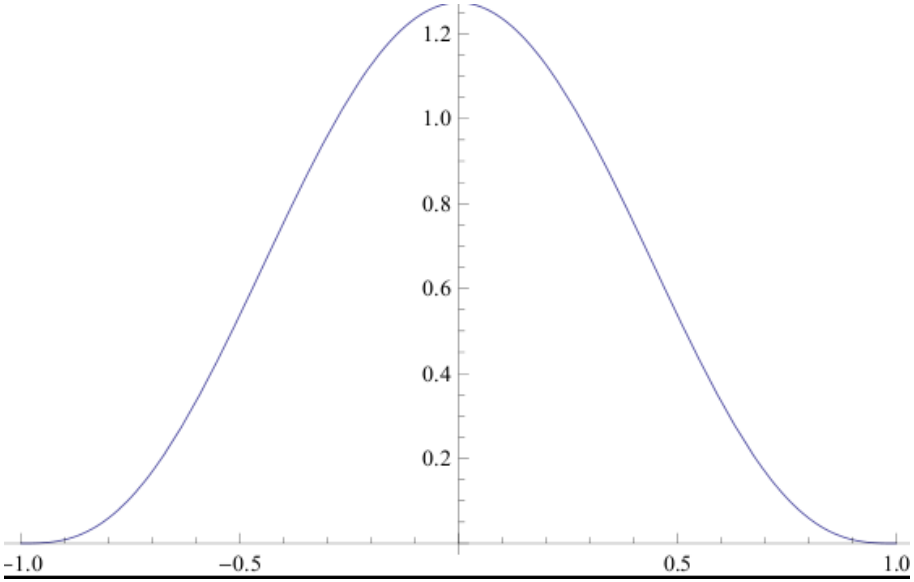
SPH - Ginhold and Monaghan (1977); Lucy (1977) – Simulation astrophysical problems



Smoothed Particle Hydrodynamics

Überblick Vorteile Parallelisierung





- Dichte/Druck/Geschw. pro Partiktel
- Gewichtung innerhalb Einflußradius
- Navier-Stokes Gleichungen
- 2D/3D Gitterfrei

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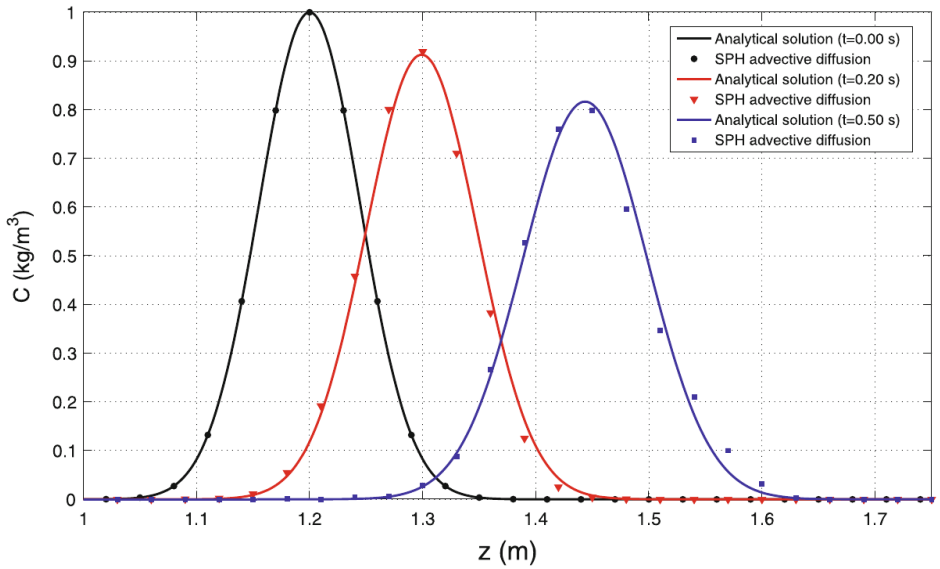
Smoothed Particle Hydrodynamics

Überblick | <u>Vorteile</u> | Parallelisierung



- Korrekte Darstellung
  - Rückstau, Überflutung
- Mehrfasen (Wasser, Luft, Teilchen)

- Korrekter Stofftransport
- Geschiebe/Schmutz

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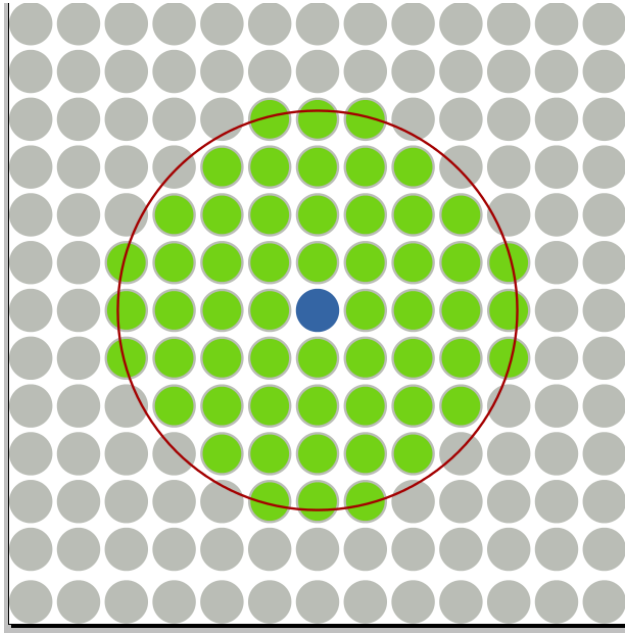
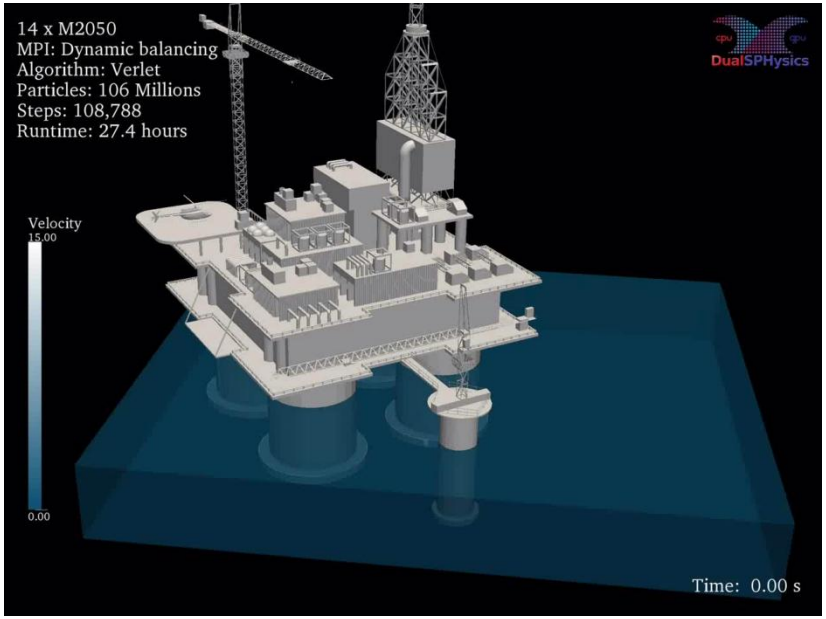
Smoothed Particle Hydrodynamics

Überblick



- ODE / Partikel
  - Navier Stokes
- Sehr viele Partikel
  - 10^8 Gesamtes Kanalnetz

Vorteile



- Nachbarschaftssuche
  - O(n^2) Worst Case
  - Gitter/Raumkurven/BVH

Parallelisierung

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Danke für Ihre
Aufmerksamkeit

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