Towards Virtual Life in 3D Cities

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Our contributions since more than 10 years

A.Aubel, R. Boulic, D. Thalmann, **Real-time Display of Virtual Humans: Level of Details and Impostors**, *IEEE Trans. Circuits and Systems for Video Technology*, Special Issue on 3D Video Technology 2000

B. Ulicny, D. Thalmann, **Towards Interactive Real-Time Crowd Behavior Simulation**, *Computer Graphics Forum*, Vol.21, No4, 2002, pp.767-776

S. Raupp Musse, D.Thalmann, Hierarchical Model for Real Time Simulation of Virtual Human Crowds, IEEE Transactions on Visualization and Computer Graphics, 2001, Vol.7, No2, pp.152-164.

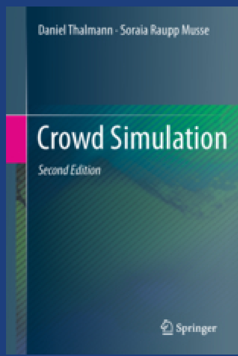
Our contributions since more than 10 years

VR-driven crowds - Miguel Garcia Arribas, 2004

H. Grillon, D. Thalmann ***Simulating Gaze Attention Behaviors for Crowds,*** *Computer Animation and Virtual Worlds*, 2009, Vol.20. pp.111-119.

P. de Heras Ciechomski, S. Schertenleib, J. Maim, D. Thalmann, D. Maupu, **Real-time shader rendering for crowds in virtual heritage**, *Proc. VAST 2005*, Pisa, Italy, pp.91-98.

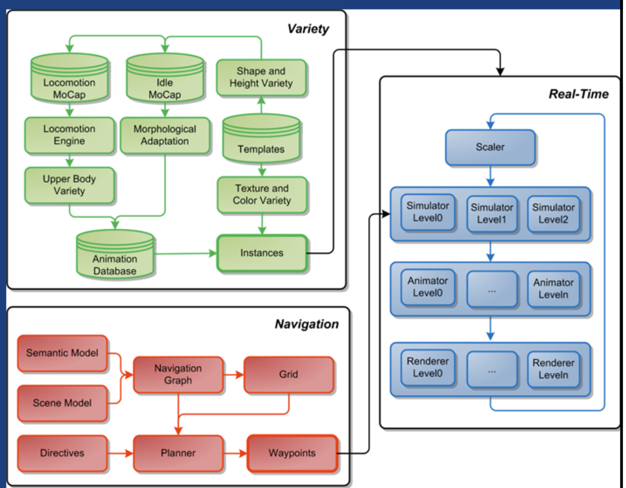
D. Thalmann, S.R. Musse, ***Crowd Simulation,*** *2nd Edition, Springer, 2012*.



YaQ Architecture Overview

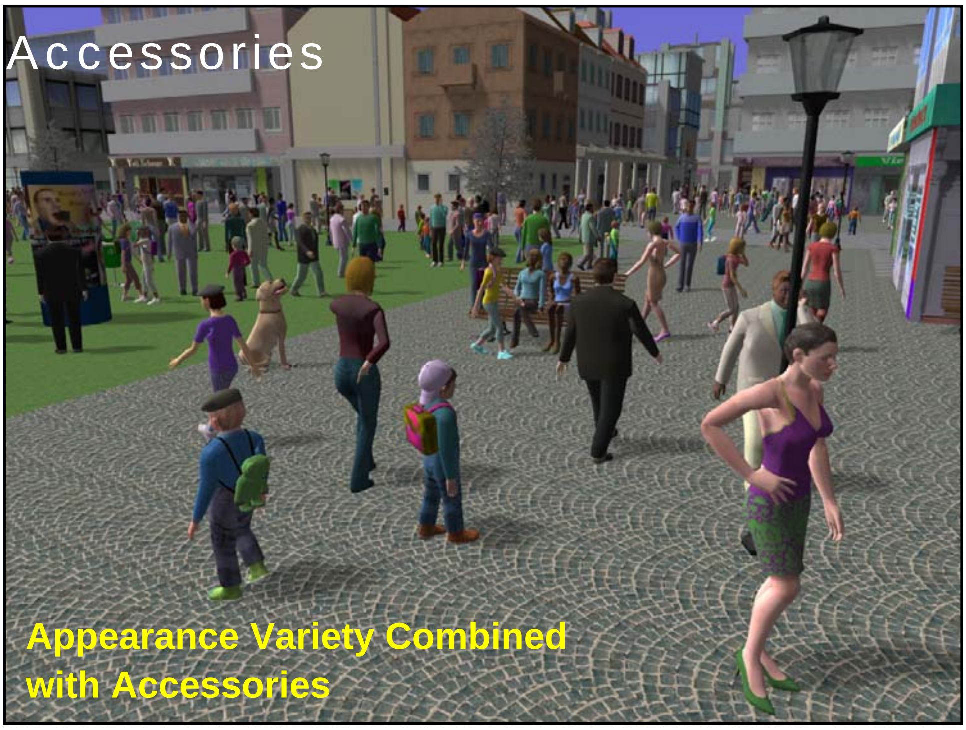
3 Components:

- Variety
- Navigation
- Real-Time



J. Maïm, B. Yersin, J. Pettré, D. Thalmann, YaQ: An Architecture for Real-Time Navigation and Rendering of Varied Crowds, IEEE Computer Graphics and Applications, Vol.29, 4, 2009, pp.44-53

Accessories



Complex Accessories (shopping bags, balloons, mugs)

- Offline:

For each complex accessory:

- Which joint to constrain
- How to constrain
  - Clamping [minAngle, maxAngle]
  - Freezing [angle]

- At runtime:

1. Update animation as usual
2. Overwrite frozen joints
3. Use exponential maps to clamp joints

B. Yersin, J. Maïm, D. Thalmann, Unique Instances for Crowds, IEEE Computer Graphics and Applications, Vol.29, 6, 2009 , pp.82-90

What is Motion Planning ?

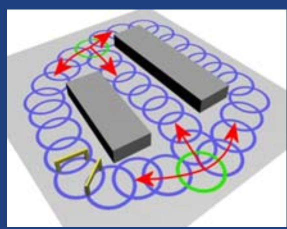
Path Planning

Collision Avoidance

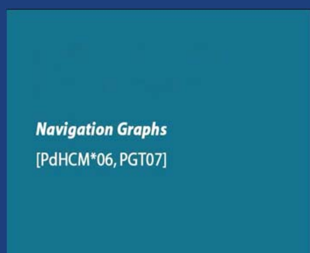
Group Cohesion

J. Pettre, P. de Heras, J. Maim, B. Yersin, J.P. Laumond, D.Thalmann, **Real-Time Navigating Crowds: Scalable Simulation and Rendering**, *Computer Animation and Virtual Worlds*, Vol.16, No3-4, 2006, pp.445-456.

Navigation Graph

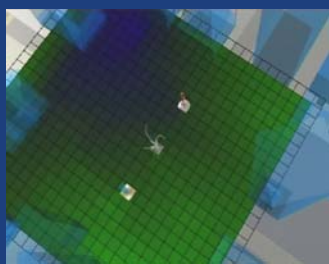


- Vertices = Walkable Space
- Edges = Gates
- Navigation Flow = Set of Paths
- Provides Next Waypoint



J. Pettre, P. de Heras, J. Maim, B. Yersin, J.P. Laumond, D.Thalmann, Real-Time Navigating Crowds: Scalable Simulation and Rendering, Computer Animation and Virtual Worlds, Vol.16, No3-4, 2006, pp.445-456.

Related Work: Continuum Crowds



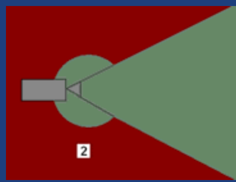
- Create a Grid
- Group Pedestrians
- Compute Potential
- Provide Next Waypoint

Adrien *Treuille*, Seth Cooper, Zoran *Popovic*: Continuum crowds. ACM Trans. Graph. 25(3): 1160-1168 (2006)

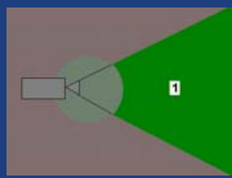
Hybrid architecture

Regions of Interest

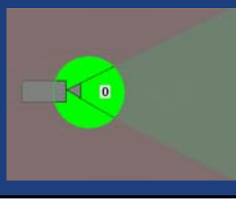
- Level 2: No Interest
  – Navigation Graph for Path Planning
  – No Dynamic Collision Avoidance



- Level 1: Low Interest
  – Ruled by Navigation Graph
  – Short - Term Obstacle Avoidance



- Level 0: High Interest
  – Ruled by Potential Fields
  – Long and Short – Term Avoidance



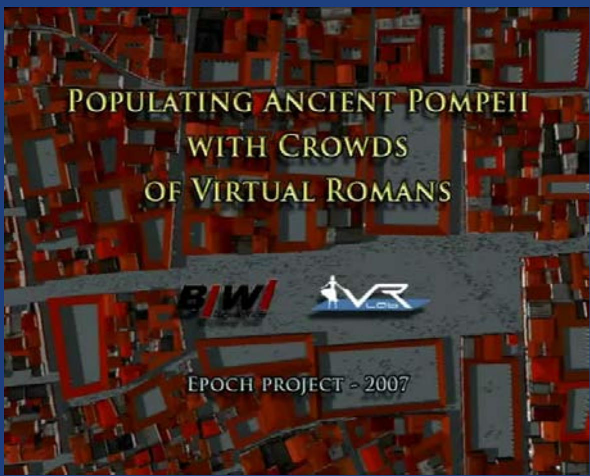
- Observation of interesting emergent behaviors, e.g., lane formations or panic effects, => crowd motion planning more realistic

F. Morini, B. Yersin, J. Maïm, and D. Thalmann, **Real-Time Scalable Motion Planning for Crowds**, *The Visual Computer*, Vol.24, No.10, pp.859-870, 2008.

Group Cohesion

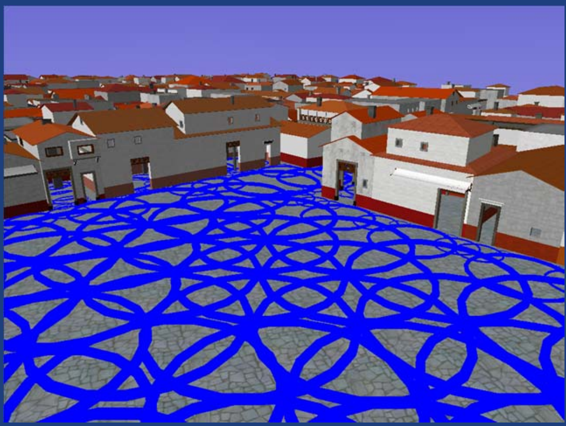
- 4 step process

1. Init: create groups
   - 2 – 4 pedestrians
   - Different templates
   - First member = leader
2. Change Security Check
   - No intwp for members
3. Speed Adaptation
   - Leader forward direction
4. Waypoint Adaptation



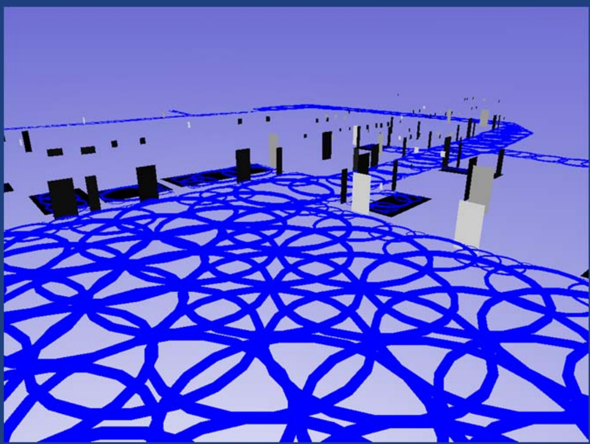
Walking – navigation graph

- Rendered geometry



Walking – navigation graph

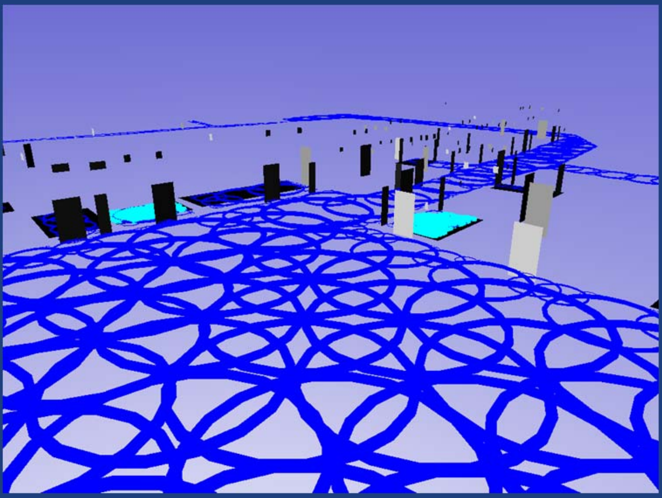
- Geometry semantics



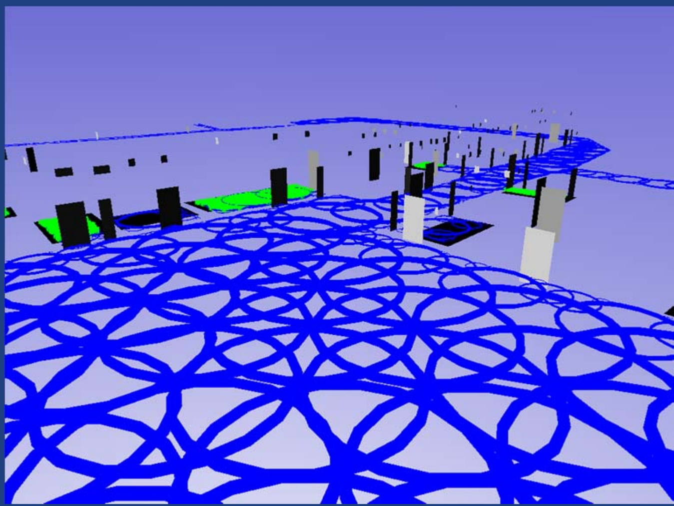
Walking – roman crowd behavior

geometry semantics	behavior	actions
shop	get amphora	walk inside, get out with amphora.
bakery	get bread	walk inside, get out with bread.
young	rich	only rich people go there.
old	poor	only poor people go there.
door	look at	slow down, look through door.
window	look at	slow down, look through window.
	stop look at	accelerate, stop looking.

Walking – shops

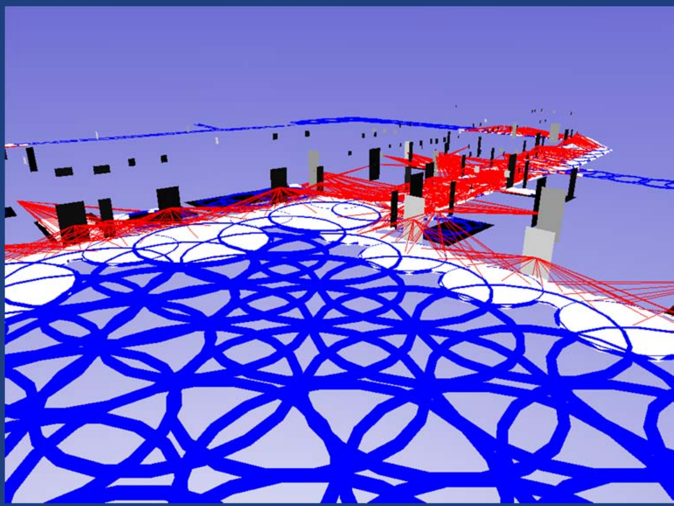


Walking – bakeries

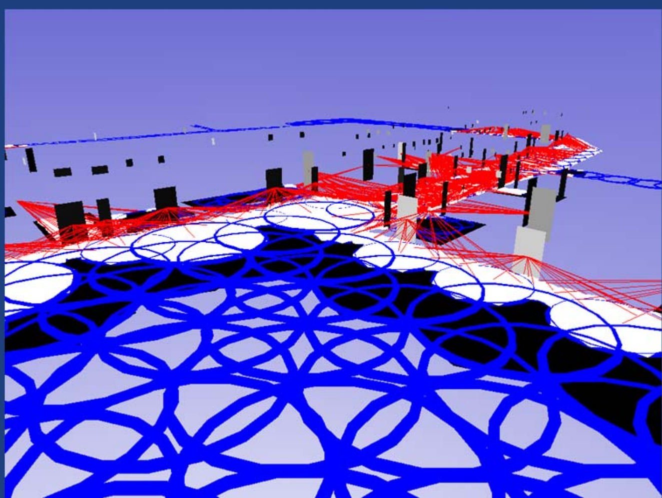


Walking – bakeries/shops result

Walking – look at



Walking – stop look at



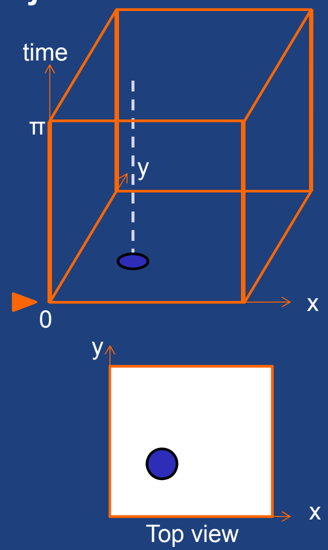
Walking – look at results

Crowd Patches

B.Yersin, J.Maïm, J.Pettré, D.Thalmann Crowd Patches: Populating Large-Scale Virtual Environments for Real-Time Applications. *Proceedings of I3D*, 2009.

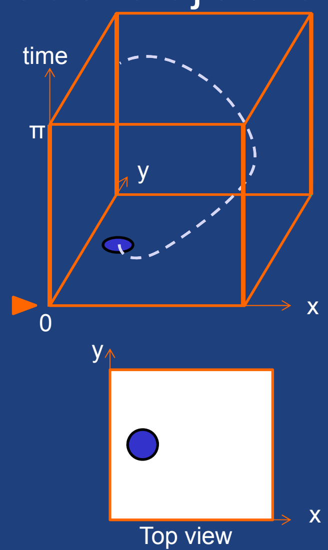
Patches: Static Objects

- No animation
- Constant position
- $\tau(0) = \tau(\pi)$
- Examples:
  - Tree
  - Signal
  - Bench
  - Trash
  - …



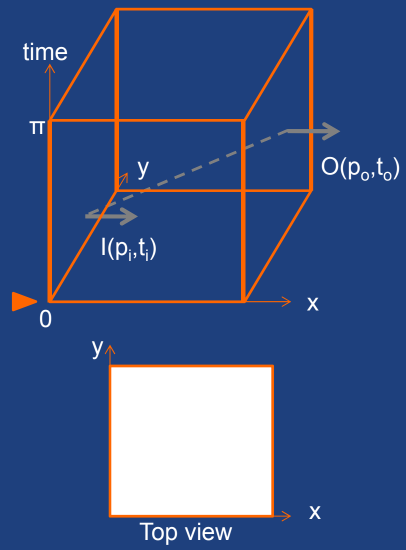
Patches: Endogenous Objects

- Animated and/or moving
- Remain inside a patch
- $\tau(0) = \tau(\pi)$
- Examples:
  - Wandering people,
  - Chatting people,
  - Wandering pets,
  - Shopping people,
  - …

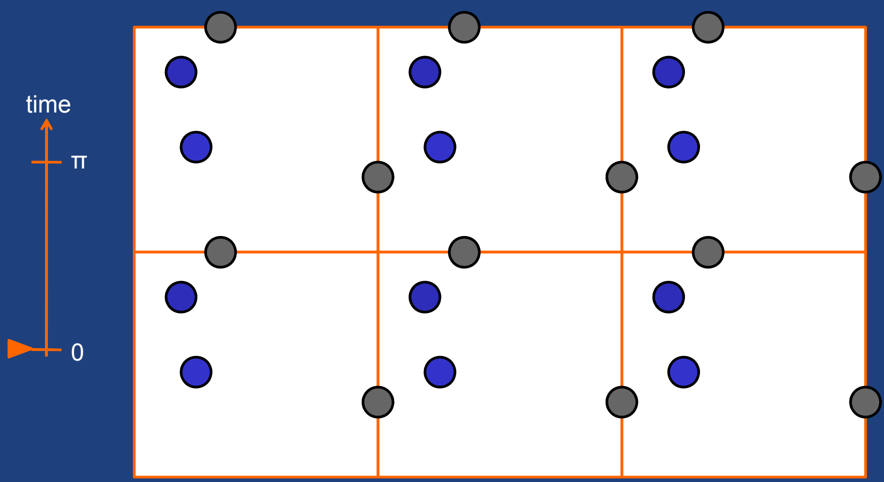


Patches: Exogenous Objects

- Animated and moving
- Enter / leave patches
- $\tau(0) = \tau(\pi)$
- Examples:
  Walking people, Cars, …



Overview



Real Trajectory Reuse

- Initial step: analysing recordings of multiple synchronized video cameras.

- Second off-line stage: fit as long as possible trajectory segments within predefined paths made of a succession of region goals.

J. Ahn, S. Gobron, Q. Silvestre, H. B. Shitrit, M. Raca, J. Pettré, D. Thalmann, P. Fua, R. Boulic, Long term real trajectory reuse through region goal satisfaction, Proc. **MIG'11:** Proceedings of the 4th international conference on Motion in Games, Springer, 2011

- Pedestrians detector integrates binary masks from cameras.
- Ground-plane partitioned into grid cells.
- In each frame, detector estimates probability of each grid cell to be occupied by a person
- Tracking algorithm efficiently solves detection association task as global optimization problem
- Finally, post-process trajectories to obtain smooth and accurate trajectories.

Long Term Real Trajectory Reuse Through Region Goal Satisfaction

Junghyun Ahn, Stephane Gobron, Quentin Silvestre, Horesh Ben Shitrit, Mirko Raca, Julien Pettre, Daniel Thalmann, Pascal Fua, Ronan Boulic

Motion in Games 2011

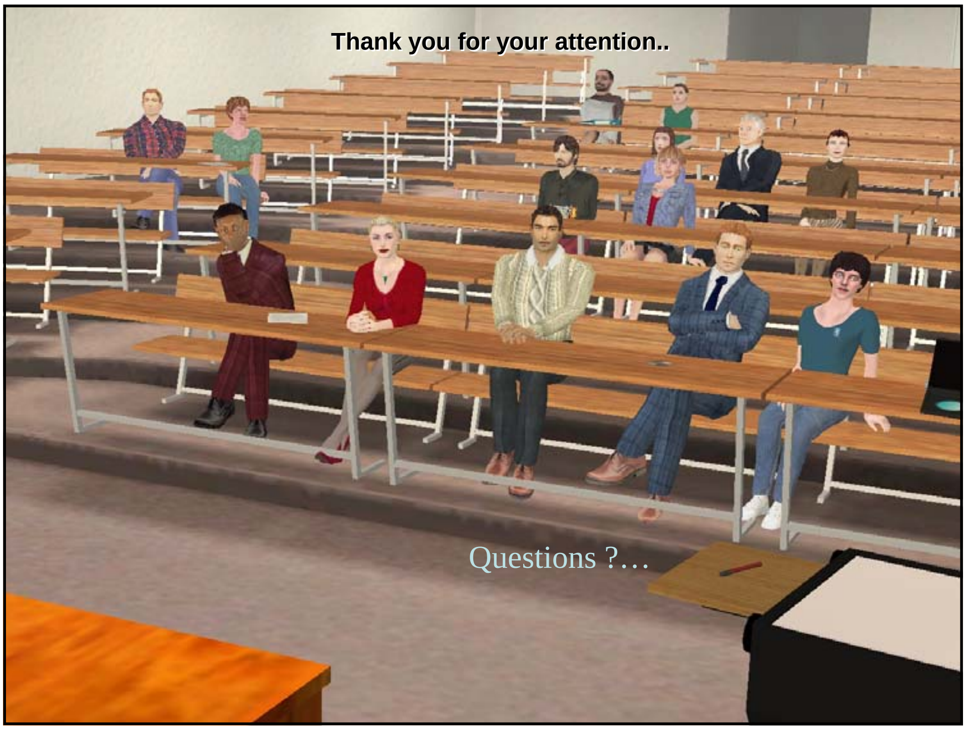
Interaction Design

- Natural interface for user
- Device
  - MS Kinect Sensor
- Method
  - Template-based gesture recognition
- Interactions
  - Walk
  - Pick
  - Direct
  - Gather
  - Disperse
  - Lead
  - Stop

Y.Wang, **R.Dubey**, N.Magnenat-Thalmann, D.Thalmann, **Interacting with the Virtual Characters of Multi-Agent Systems**, *The Visual Computer*, May 2013

Two scenarios

- gathering the agents to a specific orientation.
- making agents disperse after gathering around the avatar


Thank you for your attention..
Questions ?…