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! ($) % $ $%r&nic Gmb ' , (er in

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"ince se)era *ears +ercedes-(enz integrates simu ati&n and c&m,rehensi)e tests -ith a high degree &f aut&mati&n in the de)e &,ment ,r&cess &f aut&matic transmissi&ns. %his ,r&cess has been c&ntinu&us * im,r&)ed and e.tended. /ecent * a s& first su, , iers and engineering ser)ice ,r&)iders ha)e been integrated in this ,r&cess. 0n this ,a,er -e ,resent the current state &f the de)e &,ment ,r&cess and the c&rres,&nding t&& chain. !s an a, , icati&n e.am, e, -e use a dua -c utch transmissi&n 1D2%3 f&r ,assenger cars current * under de)e &,ment at +ercedes-(enz.

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%he c&m, e.it* &f transmissi&n s*stems is steadi * increasing, due t& gr&-ing mar4et e.,ectati&ns regarding transmissi&n efficienc*, agi it*, and fun t& dri)e. +ercedes-(enz addresses these demands -ith a gr&-ing number &f)ehic e m&de s and c&nfigurati&ns, and -ith additi&na functi&ns &f the transmissi&n s*stems, man* &f them rea ized using %25 s&ft-are. %he c&rres,&nding de)e &,ment times are c&nstant * sh&rtened, -hi e simu tane&us * 4ee,ing high 6ua it* standards.

"*stem de)e &,ment, and in ,articu ar s*stem e)a uati&n and test -ith imited res&urces 1time -ind&- and c&sts3 is theref&re a great cha enge f&r the de)e &,ment teams. 2&n)enti&na de)e &,ment and test ,r&cesses re * main * &n 1&ften m&de -based3 de)e &,ment, hard-are-in-the-&&, 1 ' i73 tests, and)a idati&n and ca ibrati&n using ,h*sica ,r&t&t*,es. Gr&-ing c&m, e.it* and imited res&urces im,&se an increasing ,ressure &n b&th 89+ and su, , iers t& further im,r&)e this ,r&cess, t& ma4e it m&re re iab e and m&re c&st-effecti)e.

!cc&rding t& these g&a s, a fe- *ears ag&, +ercedes-(enz intr&duced a ra,id integrati&n &f %25 functi&ns based &n s&ft-are-in-the-&&, simu ati&n :1, 2; and c&m,rehensi)e s*stem)a idati&n based &n aut&mated test generati&n :6, 3, <;. 0n this ,a,er, -e ,resent the current state &f this de)e &,ment ,r&cess and the c&rres,&nding t&& chain. !s an a, , icati&n

%he D2% de)e&,ment en)ir&nment integrates the f&&-ing c&m,&nents 1,art* sh&-n in Fig. 13:

- ! mu ti-d&main simu ati&n en)ir&nment used t& bui d a m&de &f the ,h*sica -&r d ar&und the %25, i.e. transmissi&n c&m,&nents and car simu ati&n. =e use the m&de ing anguage +&de ica :7;, and D*m&a as a m&de ing and c&de generati&n t&& f&r the simu ati&n m&de .
- +!%7!(>"imu in4 is used f&r m&de -based de)e&,ment &f the %25 c&ntr& s&ft-are.
- %arget7in4 turns the "imu in4 m&de 1ab&ut 1?0 m&du es3 int& high 6ua it* 2 c&de f&r t-& targets: the rea %25 and the "i7>"i)er ,atf&rm described be&-.
- ! ra,id ,r&t&t*,ing en)ir&nment is used t&)a idate the D2% ,r&t&t*,e and the %25 in a rea)ehic e and &n 'i7.
- "i)er is the t&& f&r)irtua integrati&n &f m&du es based &n "i7 simu ati&n. "i)er im,&rts b&th the transmissi&n and car m&de generated b* D*m&a and the %25 s&ft-are generated b* %arget7in4 as D77s and runs them in a c&-simu ati&n. 0n additi&n, "i)er ,r&)ides interfaces t& aut&mated s*stem test, the !27 database t& integrate ca ibrati&n data int& the simu ati&n &&,, and @2A, t& su,,&rt)irtua ca ibrati&n and measurement, much i4e in a rea car.
- 2!Ba,e is used as measurement and ca ibrati&n t&& in b&th, the rea car and b&th- [illegible] integr t

- 9ar * s*stem)a idati&n: =ith ear * a)ai abi it* &f e.ecutab e s*stem beha)i&r, s*stem beha)i&r can be)a idated against s,ecificati&ns and re6uirements. %his is the traditi&na Cfr&nt-&adingD argument : engineers are ab e t& test, debug and>&r &,timize their &-n m&du es in a s*stem c&nte.t and are n&t restricted t& m&du e tests.
- 'igh a)ai abi it*: Eirtua integrati&n ,atf&rms and setu,s are re ati)e * chea,, easi * a)ai ab e and setu,s can be re, icated e.act * -ith itt e eff&rt because the* run &n

minutes and e., &re the resu ting %25 beha)i&r b* dri)ing a)irtua car)ia "i7>"i)er &n its a,t&,. B&te: %he c&de running &n the a,t&, is the fina c&de -ith fi.-,&int arithmetics.

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+&de ica is a)end&r-neutra anguage f&r m&de ing &f ,h*sica s*stems. %he +&de ica anguage has been de)e &,ed since 1997 b* the n&n-,r&fit +&de ica !ss&ciati&n :7;. Due t& its mu ti-d&main c&nce,ts, +&de ica &ffers &utstanding su,,&rt f&r the m&de ing &f mechatr&nic s*stems, such as aut&matic transmissi&ns. ' igh 6ua it* simu at&rs f&r +&de ica are &ffered b* se)era t&&)end&rs. F&r the D2%, D*m& a -as used t& bui d a +&de ica m&de &f the D2% 1-ith&ut the %25 c&ntr& s&ft-are3, the entire)ehic e 1inc uding engine and its interacti&ns -ith the D2%3, dri)er and r&ad. D*m& a is a s& used t& generate high 6ua it* simu ati&n c&de fr&m the m&de , t& be e.ecuted in the "i7 en)ir&nment. 0n the +ercedes

- 2a ibrati&n ,arameters: "i)er can read and -rite ca ibrati&n data in D2+, A! / &r '9@ f&rmat. Ea ues can be -ritten t& fi es &r Cf ashedD fr&m fi es int& the simu ati&n.

4)

%he bui d ,r&cess f&r the "i7>"i)er target is a m&dified)ersi&n &f the bui d ,r&cess f&r the %ri2&re ,r&cess&r. (ecause c&m,i ed m&du e)ersi&ns are st&red and shared in the AE2")ersi&n management s*stem, an incrementa bui d after &n* a fe- m&du es ha)e been m&dified ta4es &n* a fe- minutes. !s &, ,&sed, a c&m, ete bui d ta4es ab&ut t-& h&urs.

!s& the %25 m&du es c&ntributed b* e.terna su, , iers are integrated in the "i7>"i)er target. %hus, a de)e &,ment engineers ha)e a c&nf&rtab e and ra,id access t& the "i7>"i)er simu ati&n &f the c&m, ete s*stem. %hus the* can test their &-n m&du es and the interacti&n -ith the rest &f the s*stem in ,ara e and inde,endent* &f each &ther. "u, , iers and engineering ser)ice ,r&)iders that c&-&,erate in the ,r&ect a s& start t& use the "i7>"i)er , atf&rm f&r integrati&n and tests. "e)era ,&tentia ,r&b ems are direct* sh&-n b* "i)er, f&r instance: mismatching signa names,)i& ati&n &f the min-ma. b&unds fr&m !27, une.,ected s*stem beha)i&r)isib e b* , &tting signa s, etc.

n additi&n, e.tensi)e tests -ith %est=ea)er are run each -ee4. During a t*,ica test, f&r instance &)er the -ee4end, &)er 2000 test scenari&s are aut&matica * generated, c assified and assessed. !s the ,r&ect is sti in a re ati)e* ear * ,hase, -e c&ncentrate m&re &n s&ft-are err&rs and a g&rithmic err&rs. (ut a s& m&re and m&re 6ua it* criteria are added t& the testing g&a s. +an* &f these criteria can be reused fr&m the %est=ea)er c&nfigurati&n f&r the 7G-%r&nic transmissi&n. !t the end &f a test se)era c&)erage and &)er)ie- re,&rts are a)ai ab e f&r sh&-ing -hat has been tested, and -hat ,r&b ems ha)e been f&und. %he ,r&b ems f&und are then assigned t& the res,&nsib e de)e &,ers. F&r the detai ed ,r&b em ana *sis and debugging the test scenari&s can be re, a*ed -ith "i)er, -here additi&na signa s can be , &tted, brea4,&ints can be set, etc.

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=e ,resented the t&& chain and ,r&cess current* used at +ercedes-(enz t& de)e &, the c&ntr& s&ft-are f&r a dua -c utch transmissi&n. %he -&r4 ,r&cess is centered ar&und a)irtua integrati&n 1"i73 , atf&rm, here "i)er :?;. %his enab es us t& ,erf&rm significant)a idati&n, test and ana *sis ste,s ear ier than in traditi&na test de)e &,ment setu,s and that &n high * a)ai ab e standard A2s a)ai ab e f&r each engineer ,artici,ating in the ,r&ect. 8rganising ,r&cesses ar&und sharing &bect fi es rem&)ed significant s*nchr&nisati&n ,&ints in the de)e &,ment ,r&cess and a &-s engineers t& assess their im,r&)ed m&du es in a s*stem c&nte.t. =hen ,r&b ems are f&und, the "i7 , atf&rm ,r&)ides a c&mf&rtab e ana *sis and debugging en)ir&nment. %he in)estment in bui ding and maintaining the "i7 , atf&rm ,r&)ed t& be -e ustified b* s,eed-u,s due t& sh&rter de)e &,ment c*c es. %he ,resented a, ,r&ach

t& s*stem)a idati&n based &n aut&mated test generati&n -ith %est=ea)er :3, <; ,r&)ed t& be ,articu ar * usefu . 8)er the entire ,r&ect, the number &f different test cases used t&)a idate the s*stem has been increased b* 2 &r 3 &rders &f magnitude, -ith&ut increasing the -&r4 &ad f&r test engineers. 8n the c&ntrar*, -e estimate that the eff&rt s,ent f&r test setu, and maintenance is n&- &n* a fracti&n &f the eff&rt re6uired f&r setting u, and maintaining the scri,t-based a,,r&ach :1;.

%he current ec&n&mic trends c&ntinue t& ,ut a high ,ressure &n 89+ and su,,iers t& further im,r&)e their de)e&,ment ,r&cess, t& ma4e it m&re reiabe and c&st effecti)e. %he !5%8"!/ standardizati&n &f the s&ft-are architectures :10; -i h&,efu* c&ntribute in this

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